NATIONAL ACCELERATOR LABORATORY

ENVIRONMENT, SAFETY & HEALTH DIVISION

Chapter 51: Control of Hazardous Energy

General Requirements

Product ID: 533 | Revision ID: 2609 | Date published: 22 April 2024 | Date effective: 22 April 2024
URL: https://www-group.slac.stanford.edu/esh/eshmanual/references/coheReqGeneral.pdf

1 Purpose

The purpose of these requirements is to prevent worker exposure to *hazardous energy* (such as from unexpected energization, startup, or release of stored energy) during service and maintenance of machines, equipment, or systems.

Service and maintenance include constructing, installing, setting up, adjusting, inspecting, and modifying machines, equipment, or systems. These terms are broad in scope and encompass a wide range of activities and equipment types. Service and maintenance also include lubrication, cleaning or un-jamming of machines or equipment, and making adjustments or tool changes where lockout is necessary to prevent workers from being exposed to the unexpected energization or startup of the equipment or release of hazardous energy.

These requirements also cover *administrative lock and tag,* which may involve the lockout of equipment for configuration or operational purposes, but which may not be used alone to protect workers from hazardous energy.

They apply to workers and supervisors; equipment designers, custodians, and owners; CoHE assessors; construction and service managers and points of contact; the CoHE program manager, and related ESH program managers.

Note Control of hazardous energy *is commonly referred to as* CoHE*, and* lockout/tagout *is commonly referred to as* LOTO *or* lockout.

1.1 Exemptions

The following activities are exempt from CoHE requirements.

- Work on *cord-and- plug connected equipment*, in which all these conditions are met:
  - There is a single energy source.
  - All of the hazardous energy is controlled by unplugging the equipment and there is no potential for stored hazardous energy.
  - The plug remains under the exclusive control of the worker performing the servicing or maintenance.
- Minor tool changes and adjustments, and other minor servicing activities that take place during normal operations, provided that (a) they are routine, repetitive, and integral to the use of the equipment, and (b) the work is performed using alternative measures which provide effective personnel protection.

(See Section 2.12, "Alternative Energy Controls", for guidance on the use of alternate measures to provide effective personnel protection.)

Service and maintenance that takes place during normal production operations requires control of hazardous energy in accordance with this program if

- A worker is required to remove or bypass a guard or other safety device, or
- A worker is required to place any part of his or her body into an area on a machine or piece of equipment where work is actually performed upon the material being processed (point of operation) or where an associated danger zone exists during a machine operating cycle.

- Activities on energized electrical equipment such as diagnostics and testing that can only be performed with the circuit energized. Workers performing these activities must follow all requirements of Chapter 8, "Electrical Safety", including safe work practices, personal protective equipment, safety analyses, work plans, and management approvals.

2 Requirements

2.1 Individual Control and Protection

The primary goal of the CoHE program is individual control over and protection from hazardous energy. The lockout procedures described below give each *authorized worker* personal control over the hazardous energy to which he or she otherwise would be exposed. Work on equipment may begin only after an authorized worker has placed his or her *personal lock(s)* on the *energy isolating device(s)* or group lock box. Each worker maintains control over the hazardous energy through application of his or her personal lock(s). No worker may work under another worker's lock. It is only when all authorized workers have removed their personal locks that the equipment may be re-energized.

Important No worker, either SLAC or subcontractor, will attempt to start, energize, or use machinery or equipment that is locked or tagged out of service by others with LOTO lock and tag, nor will any worker attempt to defeat or remove another worker's LOTO lock or tag. Failure to comply with these requirements will result in disciplinary action up to and including termination.

2.2 Subcontractors

The SLAC construction manager (CM), service manager (SM), or point of contact (POC) must ensure that the subcontractor's *affected* and *authorized workers* understand and follow the applicable provisions of SLAC's and the subcontractor's CoHE programs. In all instances, any equipment that requires a lockout will first be locked and tagged by a SLAC authorized worker or operations group, then, when authorized by the subcontractor supervisor, the subcontractor's authorized workers will apply their personal LOTO locks.

Note *If the SLAC authorized worker will not perform any work under the lockout and is not the* lead authorized worker*, then the SLAC worker should apply an administrative lock after the subcontractor has applied their CoHE lock and before the SLAC worker removes their CoHE lock.*

Note *Only SLAC* qualified electrical workers *are authorized to operate breakers and perform switching of electrical equipment.*

Subcontractors must maintain up-to-date marked-up drawings at the job site for all construction projects. These marked-up drawings must be made available to all SLAC and subcontractor workers for their use planning lockouts in support of construction activities.

2.3 Determination and Control of Hazardous Energy

An exposure to hazardous energy, such as from unexpected energization, startup, or release of stored energy, could cause serious injury or death. (Examples of potentially hazardous energy include electrical, thermal, mechanical, hydraulic, pneumatic, chemical, and ionizing and non-ionizing radiation.) For any work that might involve such exposure, a hazard analysis is required to confirm the presence of hazardous energy and determine the sources (see Control of Hazardous Energy: Hazard Analysis Procedure). If hazardous energy is confirmed a lockout procedure must be used.

2.3.1 Exposed De-energized Electrical Parts

De-energized electrical parts that have not been locked out and verified de-energized by test in accordance with a lockout procedure must be treated as energized. Only individuals who participate in the lockout in accordance with these procedures are protected from hazardous energy. Workers not participating in the lockout must treat de-energized electrical equipment as energized and remain outside the *limited approach boundary* and *arc flash protection boundary* of exposed electrical parts.

2.3.2 Control Circuit Devices

Control circuit devices such as push buttons, selector switches, and interlocks are not energy isolating devices and may not be used as a means for de-energizing circuits or equipment for the purpose of lockout. Interlocks for electric equipment may not be used as a substitute for lockout tag out procedures. In particular, personnel protection systems (PPS) and door switch interlocks (on panels, cabinets, or equipment) are not acceptable as a substitute for a lock and tag for service or maintenance.

2.3.3 Mechanical Movement

Workers must never use their own bodies to stop moving equipment parts (for example, rotating gears, fans, fan belts, pulleys, flywheels, and rolling or pressing components). The motion must be allowed to stop on its own. Parts that could move and cause injury must be blocked or braced.

On multiple fan systems, all fans must be locked out to prevent windmilling. If not all fans can be locked out, a piece of four-by-four wood or heavy-duty cable or chain and lock must be used to prevent movement of the locked-out fan(s).

2.3.4 Electrical Energy Isolation Devices

Wherever possible, workers must verify visually that all blades of electrical disconnecting devices are fully open and that drawout-type circuit breakers are open and withdrawn to the fully disconnected position. Rackable motor control center (MCC) buckets must be fully withdrawn with the breaker open.

2.3.5 Documentation for Lockout Planning

Drawings and documents are a primary resource for workers in planning lockouts. These drawings and documents must be maintained accurate and up to date by the employer (the SLAC departments responsible for the document content). When up-to-date drawings and documents are not available the employer is responsible for providing to workers an equally effective means of locating, isolating, and locking out all sources of potentially hazardous energy. Workers must notify their supervisor or line manager if they have concerns regarding the accuracy of drawings and documents used for planning lockouts. The supervisor or manager must address these concerns before implementation of the lockout.

See Section 2.2 for the requirement to maintain up-to-date marked up drawings at construction job sites for use by workers in planning lockouts. Workers contact the construction manager or project engineer to obtain access to the marked-up drawings.

2.3.6 Safety-related Maintenance

Safety-related maintenance is maintenance that preserves or restores the condition of electrical equipment for the safety of employees who work where exposed to electrical hazards. Electrical equipment must be maintained in accordance with manufacturers' instructions or industry-consensus standards to reduce the risk of failure and the subsequent exposure of employees to electrical hazards.

Workers and their supervisors must consider the condition of maintenance of electrical equipment before operating the equipment. Improper or inadequate maintenance can result in increased equipment failure rates, including increased opening time of overcurrent protective devices, thus increasing arc-flash incident energies. Where equipment is not properly maintained, the worker's personal protective equipment may not provide adequate protection from arc-flash hazards.

The employer (the SLAC departments responsible for equipment maintenance) is responsible for establishing maintenance programs that preserve or restore the condition of equipment to a state that does not present an undue hazard to workers during equipment operation. Workers are responsible to notify their line manager or supervisor if they have concerns regarding the maintenance status of equipment to be operated when implementing lockouts. The manager or supervisor must address these concerns before implementation of the lockout.

2.4 Lockout Types and Procedures

Lockouts are either simple or complex, and requirements vary accordingly.

2.4.1 Simple Lockout

A *simple lockout* is when the machinery, equipment, or system to be worked on meets all the following conditions:

- Has a single source of hazardous energy that can be readily identified, isolated, and locked out; and that single source controls all hazards, with no potential for stored energy
- Involves only one department, group, craft, or employer, and does not involve a shift change
- Contains no potential to release a hazardous material

2.4.1.1 Written Plan of Execution

A simple lockout requires a written *plan of execution* that identifies the lockout steps for the specific piece of equipment, or for multiple pieces or equipment where a single plan suffices.

A *simple lockout procedure* may be used (see Control of Hazardous Energy: Simple Lockout Procedure or a custom plan) or an *equipment-specific lockout procedure (ELP)* or a *group lockout procedure* if desired (for example, if more than one worker from the same crew is involved).

Note *A simple lockout procedure may be used for locking out multiple molded case breakers in a panelboard with a single cable-type lockout device.*

2.4.1.2 Training

Only authorized workers who are current in ESH Course 157PRA, Simple and Complex Lockout/Tagout for Authorized Workers Practical (ESH Course 157PRA), are permitted to execute a lockout. Workers qualified in ESH Course 157JN, Joining Established Group Lockout/Tagout for Authorized Workers Practical (ESH Course 157JN), may join but not establish a lockout.

2.4.2 Complex Lockout

A *complex lockout* is when one or more of the following conditions exist:

- Multiple energy sources
- Multiple crews
- Multiple crafts
- Multiple locations
- Multiple employers
- Multiple disconnecting means
- Particular sequences of operation are necessary to establish the locked-out condition safely
- Work involves a shift change

At SLAC, complex lockout may only be performed under an ELP (Section 2.4.3) or a group lockout procedure (Section 2.4.4). A simple lockout procedure may not be used for complex lockout.

2.4.2.1 Written Plan of Execution

Following National Fire Protection Association (NFPA) 70E, “Standard for Electrical Safety in the Workplace” (NFPA 70E), a complex lockout requires a written *plan of execution* that identifies a *lead authorized worker* and provides accountability for all workers participating in the lockout. For complex lockout under an ELP, the ELP itself with a complex lockout permit constitutes the written plan of execution; under a group lockout procedure, the procedure with an energy isolation plan (EIP) and a complex lockout permit constitutes the written plan of execution.

Complex Lockout Permit

A permit is required for all complex lockouts. The permit is used to identify the lead authorized worker and communicate the state of the lockout to all workers (see Control of Hazardous Energy: Complex Lockout Permit for a recommended template). The permit also provides accountability of all persons working under the lockout.

The identity of the lead authorized worker must be recorded on the complex lockout permit. When the lockout is complete and the equipment is safe for work the lead authorized worker signs the permit and, if a group lockbox used, applies a group lockout master lock and orange master lock tag to the group lockbox. Workers sign the complex lockout permit and affix their personal lock(s) to the energy isolating devices or, if used, the group lockbox, before beginning work.

Upon completion of work the workers sign off the permit and remove their personal lock(s) from the energy isolating devices or group lockbox. After all workers are signed off and locked off the lead authorized worker may lock off and the system may be restored.

2.4.2.2 Training

Only authorized workers who are current in ESH Course 157PRA, Simple and Complex Lockout/Tagout for Authorized Workers Practical (ESH Course 157PRA), are permitted to execute a lockout. Workers qualified in ESH Course 157JN, Joining Established Group Lockout/Tagout for Authorized Workers Practical (ESH Course 157JN), may join but not establish a lockout.

2.4.2.3 Roles and Responsibilities

Lead Authorized Worker

Complex lockouts require designation of a *lead authorized worker*. The lead authorized worker (who must be an *authorized worker*) carries responsibility for the entire group, including addressing worker concerns before work begins. The lead authorized worker must be knowledgeable in both the equipment to be locked out and the work scope to be performed.

Note *A member of the group performing the work is not always the best choice for lead authorized worker. In some cases, a member of the owning or custodial group may be the best choice, even though that group is not involved in the hands-on work. The key requirement is that the lead be knowledgeable in both the* ***work scope*** *and the* ***equipment****. Any of the following may be a good choice: work group member; custodial group member; operations group or operations group member; area manager; field construction manager; project engineer; system engineer; ACC/SPEAR3 operator; safety coordinator.*

Note *For complex lockouts involving only one worker, that worker is the de facto lead authorized worker.*

For an ELP, the *equipment custodian*, in consultation with the responsible manager or supervisor, designates the lead authorized worker. For a group lockout procedure, the responsible manager or supervisor designates the lead.

The lead authorized worker will

- Ensure a written plan of execution is developed and followed

- Be accountable for safe execution of the lockout
- Address worker concerns before commencing work
- Coordinate multiple work groups and work scopes
- Provide continuity of protection (see Section 2.4.2.5) for all workers for the duration of the lockout
- Ensure each authorized worker 1) affixes a personal lock to the group lockout device, group lockbox, or comparable mechanism before beginning work, and 2) removes those devices when finished working on the machine or equipment being serviced or maintained

Authorized Worker

Each authorized worker must review the energy isolation steps in the ELP or EIP. Worker concerns must be addressed before beginning work. Each worker has the right to walk down the energy isolation points to confirm proper energy isolation before beginning work. The worker then signs the complex lockout permit and affixes his personal lock(s) to the energy isolating devices or, if used, the group lockbox or multi-lock hasp, before beginning work. The worker should remain locked on until his work is complete.

Upon completion of work the worker signs off the permit and removes his personal lock(s) from the energy isolating devices or group lockbox. After all workers are signed off and locked off the lead authorized worker may lock off and the system may be restored.

For ELPs, any authorized worker may implement an ELP if the equipment custodian consents. The equipment custodian has the option to require that authorized workers be individually qualified and listed by name on a particular ELP if it is unusually complex.

Authorized workers must never attempt to start, energize, or use machinery, equipment, or systems that have been locked out by others, nor attempt to defeat or remove another worker's LOTO lock or tag.

Affected Worker

An *affected worker* is one who operates machines or equipment on which servicing or maintenance is performed under lockout, or whose job requires him/her to work in an area in which such servicing or maintenance is performed.

Affected workers must be notified before equipment is locked out and after the lockout is removed.

Affected workers must never attempt to start, energize, or use machinery, equipment, or systems that have been locked out by others, nor attempt to defeat or remove another worker's LOTO lock or tag.

Operations Group

Members of an operations group may establish energy isolation in accordance with an ELP or group lockout procedure for systems under their control. Energy isolation devices are locked out with operations locks. *Operations locks* are a set of red locks owned by a department or group that are used exclusively for an ELP or group lockout procedure and for no other purpose.

When an ELP or group lockout procedure is implemented by an operations group, the functions and responsibilities of the lead authorized worker may be transferred to the operations group. When this is the case the operations group places the group lockout master lock and orange master lock tag on the group lockbox (see 2.4.2.4, "Group Lockbox", and 2.10.5, "Group Lockout Master Lock"). The operations group

must designate an on-shift worker to perform lead authorized worker functions whenever work is in progress under the lockout. Authorized workers working under the lockout must be notified of this designation.

2.4.2.4 Group Lockbox

Group lockboxes may be used for either simple or complex lockouts; the following describes their use for complex lockouts. For simple lockouts, a permit and sign on/off by each authorized worker are not required.

Each energy isolating device must be locked. Two methods are available for lockout of individual energy isolating devices: (1) the lead authorized worker's personal locks are applied to each device; or (2) operations locks are applied to each device.

For both methods, if using a group lockbox the key for each lock is placed in the group lockbox.

Each lock on each energy isolating device must be accompanied by a tag that identifies and provides contact information for the lead authorized worker or operations group applying the lock and tag, and for group lockout procedures, a unique identifier for the group lockout (see Section 2.10, "Lockout / Tagout Equipment").

Once energy isolation, including zero energy verification, is complete, a group lockout master lock and orange master lock tag are applied to the group lockbox. The master lock provides continuity of protection for all workers. The master lock and orange master lock tag are applied before any authorized workers lock on to perform work under the lockout and must remain in place until all work is complete and all authorized workers have removed their personal locks and tags from the group lockbox. (See Section 2.4.2.5, "Continuity of Protection.")

The master lock must be keyed differently from the energy isolating device locks. A master lock may be a lead authorized worker personal lock or an operations lock (see Section 2.10, "Lockout / Tagout Equipment").

- When the master lock is a lead authorized worker personal lock, the key must remain under the exclusive control of the lead authorized worker. The lead authorized worker applies the master lock to the group lockbox whether or not he or she will actually be in the hazard zone of the equipment during service or maintenance.
- When the master lock is an operations lock, the key(s) to the master lock must remain under exclusive control of the operations group members.

After the master lock and orange master lock tag are applied to the group lockbox, authorized workers then sign on the complex lockout permit and lock on to the group lockbox before performing any work. Each worker who will perform work under the lockout must sign on and lock on the group lockout.

Alternative to Group Lock Box

A lockout involving only a few energy isolating devices and a few workers may be performed using multi-lock hasps in lieu of a lockbox. If hasps are used then a hasp should be placed on each energy isolating device, and each worker must apply a personal lockout/tagout lock on each hasp. To ensure continuity of protection, the lead authorized worker must be the first to lock on each hasp, and the last to lock off each hasp after work is complete.

2.4.2.5 Continuity of Protection

The lead authorized worker must be the first to lock on and the last to lock off the energy isolating devices called out in the ELP or EIP, and, if used, the group lockbox or multi-lock hasp, with the following two exceptions:

1. Authorized workers may lock on to the energy isolating devices or group lockbox to perform activities associated with establishing the lockout, such as zero voltage verification.
2. An administrative lock and tag may be applied to the energy isolating devices or group lockbox for the purpose of configuration control. Whenever an administrative lock and tag is used, the lead authorized worker retains responsibility for the integrity of the lockout, including re-verifying proper energy isolation if necessary before placing the master lock and orange master lock tag on the group lockbox.

For either exception, no work may be performed under the lockout until the lockout is complete and, for group lockout, the group lockout master lock and orange master lock tag are applied to the group lockbox.

For work across multiple shifts a lead authorized worker must be designated for each shift. All authorized workers on shift must be informed of this designation. Oncoming lead authorized workers must apply their own lock(s) to the energy isolating devices or, if used, the group lockbox. The off-going lead authorized worker will communicate with the oncoming lead authorized worker to ensure proper coordination of work scopes and work groups across multiple shifts. Oncoming lead authorized workers must stay locked on the energy isolating devices or, if used, the group lockbox until work on their shift has been discontinued, or until their lead duties have been transferred to another lead authorized worker.

2.4.2.6 System Restoration

System restoration must conform to Section 2.7, “Release from Lockout / Tagout“. The sequence of steps to restore equipment to service should proceed as described in the ELP or, for a group lockout procedure, in reverse sequence listed in the EIP. If alternate sequencing is desired then a job-specific restoration plan must be prepared by a knowledgeable worker who is familiar with the equipment and associated hazards. System restoration is coordinated by the lead authorized worker or operations group members.

2.4.3 Equipment-specific Lockout Procedure

An *equipment-specific lockout procedure (ELP)* is typically prepared for standalone equipment or equipment assemblies that require lockout of multiple energy sources. A single ELP may be used for multiple identical equipment assemblies. An ELP may be used for simple or complex lockouts.

Note *For large, complicated or system-level lockouts that involve many energy isolation points, multiple work groups or employers, or multiple work locations, a group lockout procedure is typically prepared.*

2.4.3.1 Required Elements

An ELP must include the following elements (see Control of Hazardous Energy: Equipment-specific Lockout Procedure (ELP) Template for a recommended template):

1. Concurrence/approval/validation: the name, title, and date of all parties who approved, tested, or revalidated the procedure
2. Procedure name, scope, and purpose

3. Equipment: complete description (model, serial number, property control number, et cetera) and location
4. Equipment custodian and the custodian(s) of any associated/affected equipment: name and contact information
5. Potentially hazardous energy sources and types (see Control of Hazardous Energy: Hazardous Analysis Procedure): include all sources, such as electrical, thermal, mechanical, hydraulic, pneumatic, chemical, and ionizing and non-ionizing radiation
6. Isolation device associated with each energy source: identity and location and if applicable schematics and/or photos
7. Preparation and notification: steps to prepare the work area, notify the equipment custodian, and all affected workers of the lockout (and the equipment custodian(s) of any associated or affected equipment)
8. Equipment shutdown procedure: for placement, removal, and transfer of lockout and/or tagout devices and the responsibility for them
9. Energy source(s) isolation: description of method(s)
10. Stored energy dissipation: description of method(s)
11. Zero energy verification, including verification of non-operation, and zero voltage verification (ZVV) (if required): description of method(s) for testing (see Control of Hazardous Energy: Zero Voltage Verification Procedure)
12. Equipment testing: if testing is required during or after service/maintenance, description of a safe testing procedure.

    Note *If any part of the lockout is removed for testing or other reasons, zero energy verification, including ZVV, will be required again once the unlocked equipment is re-locked/re-tagged.*

13. System restoration steps: for restoring system when work is complete; must comply with Section 2.7, "Release from Lockout / Tagout"
14. Designated authorized workers who are pre-approved to implement the ELP, if applicable: names
15. A complex lockout permit (sign on/sign off form) to record the identity of the lead authorized worker and to provide accountability of all persons working under the ELP

    Note *If an existing ELP does not include a complex lockout permit, a standalone permit must be used (see Control of Hazardous Energy: Complex Lockout Permit for a recommended template).*

ELP steps must be performed in the order stated in the procedure, unless alternate sequencing is specifically addressed in the ELP.

2.4.3.2 Development and Approval

The equipment custodian writes or, in consultation with the responsible manager or supervisor, ensures that a knowledgeable worker familiar with the equipment is designated to write an ELP and another knowledgeable worker is designated to be the lead reviewer. The ELP preparer and lead reviewer must be current in their training. For ELPs involving research and development or experimental equipment the ELP author and lead reviewer must be *competent persons* as defined in this chapter. Each ELP must be reviewed and approved before it is implemented the first time.

2.4.3.3 Annual Revalidation

Every ELP must be revalidated by a same-system or equipment authorized worker once per year unless an ELP has not been used within the past 12 months. In this case, the ELP must be revalidated at the next use. If the ELP is accurate, the revalidation must be documented on its approval and validation page. If the ELP is found to be inaccurate, a redlined copy must be forwarded to the equipment custodian for resolution.

2.4.4 Group Lockout Procedure

A group lockout procedure is typically used for large, complicated, or system-level lockouts that involve many energy isolation points, multiple work groups or employers, or multiple work locations, although it may also be used for simple lockout. (See Control of Hazardous Energy: Group Lockout Procedure.)

Under group lockout a *lead authorized worker* coordinates multiple authorized workers and work scopes to be worked under the group lockout.

Note *For standalone equipment or equipment assemblies that require lockout of multiple energy sources, an ELP is typically prepared.*

2.4.4.1 Energy Isolation Plan (EIP) Development

Group lockout energy isolation must be carried out under a written *energy isolation plan (EIP)* that is developed in accordance with Control of Hazardous Energy: Group Lockout Procedure. The plan must include

- A unique group lockout identifier that will applied to all associated forms and tags
- A separate step for locking and tagging each individual energy isolating device. Each device must have its own step.
- A separate step for each individual zero energy verification, verification of non-operation, and release of stored energy. Each verification/release must have its own step.
- Drawings or sketches that identify energy isolating devices, if needed to assist authorized workers in understanding the EIP

The responsible manager or supervisor, in consultation with the equipment custodian, must designate a knowledgeable worker familiar with the equipment and work scope to prepare the EIP and a second knowledgeable worker to review it. EIP preparers and lead reviewers must be current in the required training. In some cases a member of the owning or custodial group may be the best choice to prepare or review an EIP, even though that group may not be involved with the servicing or maintenance activities.

For a recommended EIP template, see Control of Hazardous Energy: Group Lockout Energy Isolation Plan Template. An EIP may be reused but it must be reviewed and approved for each use.

Energy isolation steps must be implemented in the order stated on the EIP unless alternate sequencing is specifically addressed in the plan.

2.4.5 Zero Energy Verification

The zero energy state is the lowest achievable energy state for machinery, equipment, or systems. Achieving zero energy state is unique to each lockout, depending on the equipment and energy source. Generally, the zero energy state is achieved by

- Attempting to start the equipment using normal operating controls to check that the equipment does not start or become energized (verification of non-operation).
  - Return the operating control(s) to the NEUTRAL or OFF position before proceeding with servicing or maintenance work
- De-energizing electrical energy sources, including discharging capacitive and inductive elements (absence of voltage, current, and stored electrical energy). See Section 2.4.5.1 for *zero voltage verification*.
  - Where the potential for re-accumulation of electrical energy exists, apply grounding devices such as ground hooks or grounding clips and wire
- Totally blocking or releasing mechanical (kinetic or potential) energy, including movement such as fan windmilling and equipment with stored spring energy (such as switchgear breakers)
- Allowing surface or liquid temperatures to moderate to prevent thermal burns
- Removing all differential pneumatic or hydraulic pressure to equal atmospheric pressure
  - Use temporary or permanently installed pressure indicators to confirm zero pressure
  - When blank flanges are used, install a fitting to attach a pressure indicator to the blank flange if no other pressure indicator is available within the lockout boundary
  - Always include a locked open vent valve or drain valve (or both) in the lockout procedure to prevent re-accumulation of pressure while the lockout is in place

Note *If any part of the lockout is removed for testing or other reasons, zero energy verification, including ZVV, will be required again once the unlocked equipment is re-locked/re-tagged.*

2.4.5.1 Zero Voltage Verification

When work is to be performed within the *limited approach boundary* or *arc flash protection boundary* of exposed electrical parts a *zero voltage verification* must be performed. Zero voltage verification is performed after verification of non-operation (Section 2.4.5).

A qualified electrical worker using an appropriately rated meter must test all circuit elements and electrical parts to which workers may be exposed. The qualified electrical worker must lock on to the lockout before performing any tests. (See Control of Hazardous Energy: Zero Voltage Verification Procedure).

In addition to the zero voltage verification, electrical workers should use a proximity tester or other voltage testing device to periodically confirm absence of voltage at the work location (that is, liberal use of “test before touch”) including after pauses in work or if the work site has be left unattended. Non-electrical workers may request the support of qualified electrical workers to perform these tests. Electrical workers must oblige these requests.

2.5 Pauses in Work

Authorized workers should remain locked on to a lockout on until their work is complete. The single key for each personal lock must remain in the possession of the worker who placed it. When work continues beyond one work day, each worker must verify that his or her lock is still in place before beginning work each day. If a lock is removed for any reason, the worker must re-verify proper energy isolation before locking on and resuming work.

2.6 Lock and Tag Removal for Testing

An authorized worker may temporarily remove his or her lock(s) and tag(s) for the purpose of testing machines, equipment, or a process, or to carry out any other necessary sub-task such as positioning equipment. When locks are removed for testing the lockout is no longer intact and no work may be performed. All workers must remain clear of the equipment hazard zone.

After completing testing or positioning, the authorized worker must implement safe de-energization and zero energy/voltage verification and replace locks and tags before continuing with the original task.

For complex lockouts, the lead authorized worker must coordinate lock removal for testing, and restoration of the lockout following testing. All workers must be informed of the test activities, and no work may be performed until the lockout is re-established.

2.7 Release from Lockout / Tagout

The following equipment restoration steps apply to all lockouts:

- Check the machine/equipment and surrounding area to ensure that non-essential objects have been removed, guards have been reinstalled, and that the machine/equipment is operationally intact
- Verify machine/equipment controls are in the NEUTRAL or OFF position
- Verify that all affected workers and other authorized workers are out of harm's way
- Remove locks and tags and prepares to restart the machine/equipment
- Before restarting machinery/equipment, notify affected workers and the equipment custodian, equipment owner, or system owner, as applicable, that work is complete, that locks and tags have been removed, and that normal operations may proceed

The lead authorized worker coordinates these steps out for complex lockouts; the authorized worker for simple.

2.8 Alternative Process for Lockout / Tagout Device Removal

The only person authorized to remove a red personal lock and tag is the worker who applied it. If the worker is not available and is unable to return to site to remove the lock, the lock may be cut off and removed with the concurrence of the worker's supervisor or manager. The following steps must be taken (see Control of Hazardous Energy: Alternative Authorization for Removing Locks and Tags Form):

1. Verify that the worker who installed the lock is not on the site or may not return to the site
2. Make all reasonable efforts to contact the worker
3. Record in writing all the circumstances and reasons for cutting off the lock
4. Determine that it is safe to energize
5. Cut off the lock
6. Make sure that worker is informed that the lock has been removed before he/she resumes work at the job site

Note *These restrictions do not apply to removing administrative locks and tags, which are neither red nor used for worker protection (see Section 2.11, "Administrative Lock and Tag Control").*

2.9 Tagout Only

In some cases lockout may not be possible because energy isolation devices are not lockable. If an energy isolation device is not lockable, *tagout only* may be used if all the following requirements are satisfied:

- Tagout-only tags must be attached at the same location that the lockout device would have been attached.
- In demonstrating that the level of safety achieved using tagout only is equivalent to the level of safety obtained by using full lockout, the authorized person using tagout only must implement at least one additional safety measure at each energy isolation location to reduce the likelihood of inadvertent energization by doing one or more of the following:
  - Remove and tag an additional isolating circuit element (for example, fuses)
  - Lift, safe-off, and tag circuit power leads
  - Open and tag an extra disconnecting device
  - Remove and tag a valve handle
  - Post a safety guard at the energy isolating device to ensure the device remains in the isolation position. The safety guard must have no other duties and must not leave his station for any reason.
- Tagout-only tag attachment means must be of a non-reusable type, attachable by hand, self-locking, and non-releasable, with a minimum unlocking strength of no less than 50 pounds and having the general design and basic characteristics of being at least equivalent to a one-piece, all environment-tolerant nylon cable tie.

2.10 Lockout / Tagout Equipment

2.10.1 General Requirements

Important Workers must never depend upon another worker's lock(s) and must always apply their personal lock(s) to the energy isolation device(s) or group lockbox.

All necessary lockout/tagout equipment must be provided by the authorized worker's employer.

Depending on the lockout/tagout requirements for specific circumstances, required supplies may include a lock, hasp, tag, tag attachment means, chains, wedges, key blocks, adapter pins, self-locking fasteners, or other hardware. Adhesive lock labels may be used subject to the requirements of Section 2.10.6, "Lockout Tags and Adhesive Lock Labels".

Lockout devices, tags, and adhesive lock labels must meet the following requirements:

- Lockout locks and hardware and lockout tags and adhesive lock labels must be capable of withstanding the environment to which they are exposed for the maximum period of time that exposure is expected.
- Lockout locks and hardware must be substantial enough so that they cannot be removed without the use of excessive force or unusual techniques (such as bolt cutters or other metal cutting tools).
- Lockout tags, including their means of attachment, must be substantial enough to prevent inadvertent or accidental removal.
- Lockout tags and adhesive lock labels must be constructed and printed so that exposure to weather conditions or wet and damp locations will not cause the tag or label to deteriorate or the message on the tag or label to become illegible.
- Lockout tags and adhesive lock labels must not deteriorate when used in a corrosive environment, such as in an area where acid or alkali chemicals are handled or stored.

2.10.2 Personal Lock

Authorized worker *personal locks* must:

- Be red (SLAC authorized workers) or otherwise be uniquely identified (subcontractor authorized workers)
- Have only one key, and that key must remain in control of the worker (multiple locks with a single unique key are permitted)
- Not be used for any purpose other than lockout/tagout

2.10.3 Operations Lock

An *operations lock* differs from a personal lock in that they are under the exclusive control of operations group members.

Operations locks

- Must be red
- May be marked or labeled to identify the owning group
- Must not be used for any purpose other than lockout/tagout
- If used for complex lockout energy isolation, must have only one key
- If used as group lockout master locks, may have one or more keys, all of which are in the control of the group members[1]

1 This is the only red lock in the SLAC CoHE program that may have more than one key.

2.10.4 Lead Authorized Worker Lock

Lead authorized worker locks are personal locks and may be used by a lead authorized worker for group lockout energy isolation. When lead authorized worker locks and a group lockbox are used for group lockout energy isolation, the key for each lock must be placed in the group lockbox.

2.10.5 Group Lockout Master Lock

When a group lockbox is used, a *group lockout master lock* and orange master lock tag (see 2.10.6) are placed on the group lockbox to signify that energy isolation is complete and that the system or equipment is ready for maintenance or servicing.

Group lockout master locks must be red. When energy isolation is complete and the lockout has been established, the master lock is the first lock on and the last lock off the group lockbox. The master lock provides continuity of protection for all workers performing work under the group lockout. The master lock must be keyed differently from the locks used for energy isolation. The master lock may be a lead authorized worker personal lock or an operations lock.

2.10.6 Lockout Tags and Adhesive Lock Labels

All lockout locks must be accompanied by a lockout tag or adhesive lockout lock label that identifies the authorized worker who applied the lock.

- All lockout tags and lock labels must have a white background with black letters and must include a red, white, and black ANSI danger symbol.

  Exception The group lockout master lock tag has an orange background (see Control of Hazardous Energy: Tag Templates).

- Lockout tags and lock labels must state explicit instructions such as DO NOT OPERATE, DO NOT START, DO NOT ENERGIZE, DO NOT REMOVE, MY LIFE IS ON THE LINE or similar warning of the hazardous condition.
- For personal locks, including individual workers working under group lockout or an ELP, a lockout tag or lockout lock label that identifies the worker and worker contact information is required.

Note Worker name and contact information may be on an adhesive label or engraved on one side of the lock with an adhesive label containing the danger symbol and required wording on the other side.

- Group lockout tags affixed to energy isolating device locks must
  - Contain the words GROUP LOCKOUT or GROUP LOTO
  - Include a unique group lockout identifier
  - Include the name and contact information of the lead authorized worker or operations group
- Group lockout master lock tags must
  - Have an orange background with black lettering and contain a red, white and black ANSI danger symbol
  - Contain the words GROUP LOCKOUT MASTER LOCK or GROUP LOTO MASTER LOCK

- Include a unique group lockout identifier
- Include the name and contact information of the lead authorized worker or operations group who applied the lock

Note *Group lockout tags may be used for ELPs involving multiple workers.*

For tag templates, see Control of Hazardous Energy: Tag Templates.

2.11 Administrative Lock and Tag Control

The purpose of *administrative lock and tag control* is to allow workers or groups to control energy isolating devices for purposes other than the control of hazardous energy while servicing and maintenance is performed. Administrative lock and tag is typically used for exercising configuration or operational control.

Important Never rely on administrative lock and tag control when lockout/tagout for hazardous energy control is required. For servicing and maintenance of machines, equipment, or systems formal lockout is always required.

2.11.1 Requirements

Administrative lock and tag control may be used by individual workers or by groups responsible for control and maintenance of equipment, machinery, or systems. Administrative lock and tag control is commonly used when

- Equipment must be shut down because it is defective (further use may cause damage or equipment failure)
- A particular configuration must be maintained
- Equipment operation may result in undesirable consequences
- Special training or authorization may be required to use the equipment
- Newly installed equipment or systems have not yet been fully tested or approved for use
- Equipment has been removed from service and its energy source is locked off

Note *Contact the electrical safety officer for guidance on the use of administrative lock and tag to mitigate hazardous energy in out-of-service equipment. In particular, note that administrative lock and tag must not be used where one end of a cable or piping branch line has been disconnected from equipment, and the other end is connected to a source of hazardous energy.*

Another use of administrative lock and tag involves locking out equipment by a SLAC worker so that a subcontractor who will be performing work can apply the required personal lock and tag for control of hazardous energy (see Section 2.2, “Subcontractors”). If the SLAC worker will not perform work or be within the hazard zone of the equipment and is not the lead authorized worker, an administrative lock and tag should be used in lieu of a lockout/tagout personal lock and tag.

These two examples illustrate this use:

- In preparation for subcontractor service to a chiller, SLAC Facilities and Operations Division personnel shut down the chiller and apply administrative lock and tag to the chiller's energy isolating devices. The subcontractor's employees then apply their personal lock and tag before beginning work.
- In preparation for subcontractor installation of new electrical equipment, a SLAC qualified electrical worker de-energizes the circuit, applies a personal LOTO lock and tag, and performs zero voltage verification. The SLAC worker then replaces their personal LOTO lock and tag with an administrative lock and tag. The subcontractor's electricians then apply their personal LOTO locks and tags before beginning work.

2.11.2 Locks

An administrative lock may be any color but red and may have more than one key. Administrative locks may be used by an operations group, such as SLAC Facilities and Operations or Accelerator Operations, with keys accessible to multiple group members.

2.11.3 Tags

Tags used for administrative lock and tag are informational, and must not resemble red, white, and black danger tags used for control of hazardous energy.

Administrative control tags

- Must not use the lockout/tagout DANGER red, white, and black graphic. They may use DO NOT ENERGIZE, ADMINISTRATIVE LOCK AND TAG, NOTICE, INFORMATION, or similar wording, and may include department-specific language such as KTL CONTROL TAG.
- Should be distinguishable by their color in that they do not resemble the white/black/red danger tag used for lockout/tagout; blue and white is a good choice
- Should be standard size
- Must include the following information:
  - Department/organization/worker name
  - Telephone number/contact information for responsible department or person(s)
- Durable adhesive lock labels or other durable lock labeling methods may be used in lieu of tags provided the labels provide the information required above.

For tag templates, see Control of Hazardous Energy: Tag Templates.

2.12 Alternative Energy Controls

Alternative energy control requirements apply if the equipment must be energized to perform the required servicing task. When alternative energy controls are used, lockout/tagout is not required for the control of hazardous energy.

For example, in laser work, alignments, creating new beam paths, and replacing optics are servicing tasks performed with lasers partially or fully energized. These tasks require the use of alternative energy controls.

These controls must use the necessary combination of engineering controls (such as barriers and fixed guards, interlocks for moveable equipment guard devices, key control), warning and alert systems, administrative controls, and personal protective equipment to achieve effective control of hazardous energy protection for workers. These controls must be documented and reviewed and approved as follows:

- Electrical equipment: by the electrical safety officer (ESO). See Chapter 8, "Electrical Safety", in particular the requirements for preparation, review, and approval of electrical work plans (EWPs) and energized electrical work permits (EEW).
- Laser safety systems: by the laser safety officer (LSO). See Chapter 10, "Laser Safety", for alternative energy controls documented in standard operating procedures (SOPs)
- Radio frequency (rf) systems: by the non-ionizing radiation program manager. See Chapter 50, "Non-Ionizing Radiation".
- Ionizing radiation: by the radiation safety officer (RSO). See Chapter 9, "Radiological Safety"
- Machine shop / fabrication areas. See Chapter 25, "Machine and Portable Tools"

2.13 Out-of-Service Equipment

Out-of-service equipment should be placed in a safe state that is economical to monitor and maintain for an extended period, until the eventual decommissioning of the equipment. Maintaining equipment in a safe state ensures that potential hazards to workers, the public, and the environment are minimized. Elimination or mitigation of hazardous energy in out-of-service equipment should occur as soon as practicable following removal of equipment from service.

Contact the electrical safety officer for guidance on the use of administrative lock and tag to mitigate hazardous energy in out-of-service equipment.

2.14 Hot Tap Operations

Hot tap operations are processes to establish a connection to a pressurized piping system without first establishing a zero hazard state. Hot taps involve the use of specialized drilling equipment to tap into in-service, pressurized process piping for the purpose of attaching a mechanical or welded branch fitting

Hot taps are allowed only when all these conditions are met:

- Continuity of service is essential
- Shutdown of the system is impractical
- Documented procedures are followed
- Special equipment is used that will provide proven, effective protection for workers

Permission to hot tap a process system is limited to situations in which system shutdown is impossible (such as a leaking tank or other non-isolable leak) or where hot tapping is shown to be less hazardous than shutting down and locking out the system and performing a cold tap. In other words, the decision to hot tap must be safety-based. It must be shown that, on the whole, it is safer to perform the hot tap than to shut down, depressurize, and lock out the system.

The responsible person must prepare a job safety analysis (JSA) that substantiates the recommendation to perform the hot tap. The JSA may consider the hazards and risks associated with shutting down and depressurizing the system or loop, including installation of temporary power and other temporary equipment necessary for facility operation.

The JSA must be reviewed and approved by the responsible supervisor and the CoHE program manager. If the JSA does not demonstrate that the hot tap is the lower-risk path, then the hot tap will not be permitted. In that case system shutdown, depressurization, and lockout are required.

3 Procedures, Forms, and Templates

The following are required procedures:

- Control of Hazardous Energy: Hazard Analysis Procedure (SLAC-I-730-0A10C-002). Describes process for determining hazardous energy sources and provides thresholds and other references
- Control of Hazardous Energy: Simple Lockout Procedure (SLAC-I-730-0A10C-003). Describes process for performing a simple lockout (a written plan of execution is required: this procedure, a custom plan, an ELP, or a group lockout procedure may be used)
- Control of Hazardous Energy: Group Lockout Procedure (SLAC-I-730-0A10C-006). Describes process for conducting a complex, group lockout
- Control of Hazardous Energy: Zero Voltage Verification Procedure (SLAC-I-730-0A10C-004). Describes process for verifying zero voltage
- Control of Hazardous Energy: Authorized Worker Certification Procedure (SLAC-I-730-0A10C-005). Describes process for certifying authorized workers on assigned lockout procedures

The following forms and systems are required by these requirements:

- Control of Hazardous Energy: Alternative Authorization for Removing Locks and Tags Form (SLAC-I-730-0A10J-002). Form for authorizing removal of a personal red lock and tag if the person who applied it is not available and is unable to return to site
- Control of Hazardous Energy: Request for Authorized Worker Certification Form (SLAC-I-730-0A10J-010). Form for requesting certification of authorized workers
- Control of Hazardous Energy: Authorized Worker Certification Form (SLAC-I-730-0A10J-004). Form for certifying authorized workers on assigned lockout/tagout procedures (restricted access, available form the Control of Hazardous Energy Program Site [SharePoint])

The following are recommended templates. Equivalent forms may be used:

- Simple lockout plan template and instructions. Template for creating a simple lockout plan; lists required elements (available from Control of Hazardous Energy Program Site [SharePoint])
- Control of Hazardous Energy: Equipment-specific Lockout Procedure (ELP) Template (SLAC-I-730-0A10J-001). Template for creating an equipment-specific lockout procedure (ELP); lists required elements of an equipment-specific lockout procedure (ELP)
- Control of Hazardous Energy: Group Lockout Energy Isolation Plan Template (SLAC-I-730-0A10J-005). Template for creating group lockout energy isolation plans (EIPs); lists required elements of an energy isolation plan

- Control of Hazardous Energy: Complex Lockout Permit (SLAC-I-730-0A10J-006). Form for documenting lead authorized worker and sign on and sign off of workers for complex LOTO
- Control of Hazardous Energy: Tag Templates (SLAC-I-730-0A10J-003). Templates for creating tags

These are other program documents and resources:

- Control of Hazardous Energy Program Site (SharePoint). Contains additional information and documents for implementing CoHE requirements

4 Recordkeeping

The following recordkeeping requirements apply for these requirements:

- See specific procedures

5 References

SLAC Environment, Safety, and Health Manual (SLAC-I-720-0A29Z-001)

- Chapter 51, "Control of Hazardous Energy"
  - Control of Hazardous Energy Program Site (SharePoint)
- Chapter 2, "Work Planning and Control"
  - Work Planning and Control: Job Safety Analysis Form
- Chapter 8, "Electrical Safety"
- Chapter 9, "Radiological Safety"
- Chapter 10, "Laser Safety"
- Chapter 25, "Machine and Portable Tools"
- Chapter 50, "Non-Ionizing Radiation"

Other SLAC Documents

- ESH Course 157PRA, Simple and Complex Lockout/Tagout for Authorized Workers Practical (ESH Course 157PRA)
- ESH Course 157JN, Joining Established Group Lockout/Tagout for Authorized Workers Practical (ESH Course 157JN)

Other Documents

- National Fire Protection Association (NFPA) 70E, "Standard for Electrical Safety in the Workplace" (NFPA 70E)