

Chapter 51: [Control of Hazardous Energy](#)

# Hazard Analysis Procedure

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URL: <https://www-group.slac.stanford.edu/esh/eshmanual/references/coheProcedHazAnalysis.pdf>

## 1 Purpose

The purpose of this procedure is to determine if the *energy source(s)* associated with *service or maintenance* performed on any machinery, equipment, or system has the potential to harm workers. If so, the *hazardous energy* must be controlled using an appropriate *lockout* procedure (see [Control of Hazardous Energy: General Requirements](#)). This procedure covers determining whether hazardous energy may exist. It applies to workers, supervisors, equipment custodians, and area and building managers.

## 2 Procedure

Step	Person	Action
1.	Responsible manager or supervisor or equipment custodian	Assigns a worker to conduct a hazard analysis (or to confirm there is an existing <i>equipment-specific procedure [ELP]</i> or <i>energy isolation plan [EIP]</i> for the work). For group lockouts using new ELPs or EIPs, the hazard analysis is prepared by the ELP/EIP preparer. For other lockouts, the hazard analysis is prepared by an <i>authorized worker</i> , familiar with the equipment and work scope.
2.	Worker	Reviews the scope of work and affected machine, equipment, or system
3.	Worker	Identifies all energy sources (electrical, mechanical, thermal, potential, pneumatic, hydraulic, chemical, and radiological, et cetera) (see Section 2.1, “Energy Types: Additional Information and References”)
4.	Worker	Determines if any energy sources are hazardous (see Table 1) <ul style="list-style-type: none"> <li>▪ If the value of the hazardous energy falls in the “Evaluate Hazard and Consider Lockout” column, lockout should be used if the authorized worker determines that lockout is warranted based on an evaluation of all hazards, including secondary hazards and combined hazards, associated with the work scope and equipment or system conditions; otherwise lockout is not required.</li> <li>▪ If the value falls in the “Lockout Required” column, lockout is required.</li> </ul> For energy types without an explicit value, consults additional applicable resources to make a determination (such as information in this document and relevant ESH Manual chapters, and the control of hazardous energy [CoHE] program manager, responsible directorate ESH coordinator, safety officer, and subject matter experts)
5.	Worker	Evaluates each task including setup, installation, removal, adjusting, cleaning, troubleshooting, and programming to analyze for hazards
6.	Worker in consultation with building or area manager, if necessary	Evaluates the work environment for potentially hazardous combinations (see “Potentially Hazardous Energies in Combination” below)
7.	Worker	For <i>complex lockouts</i> , documents results of the hazard analysis in an ELP or EIP and submits for approval (or confirm the adequacy of the existing ELP or EIP)

**Table 1** Hazardous Energy Thresholds

Energy Form	Evaluate Hazard and Consider Lockout	Lockout Required
Electrical (AC or DC)	< 50 V and $\geq$ 5 mA or $\geq$ 50 V and < 5 mA or > 0.25 J and $\leq$ 10 J stored energy	$\geq$ 50 V and $\geq$ 5 mA or < 50 V and $\geq$ 1000 W or > 10 J stored energy
Thermal (hot)	Liquids or gases $\leq$ 125°F (52°C) Surfaces $\leq$ 140°F (60°C)	Liquids or gases > 125°F (52°C) Surfaces $\geq$ 140°F (60°C)
Thermal (cold)	Liquids and surfaces $\geq$ 27°F (-3°C)	Liquids and surfaces < 27°F (-3°C)
Magnetic fields	No threshold with respect to control of hazardous energy; each situation must be evaluated. Refer to <a href="#">Chapter 50, "Non-ionizing Radiation"</a> , for magnetic field exposure limits.	
Kinetic	No threshold; each situation must be evaluated	
Potential	No threshold; each situation must be evaluated	
Pneumatic and hydraulic	No threshold; each situation must be evaluated	
Chemical	No threshold: each situation must be evaluated based on the chemical's hazardous properties	
Non-ionizing radiation other than lasers (3 kHz to 300 GHz, or > 1 mm)	Many sources of non-ionizing electromagnetic radiation involve electrical hazards that must be considered even when the radiation emitted is not hazardous. See <a href="#">Chapter 50, "Non-ionizing Radiation"</a> , for requirements and maximum permitted exposures (MPEs)	
	$\leq$ MPEs	> MPE
Lasers (180 nm to 1 mm)	Class 3B or Class 4 lasers: use lockout or controls equivalent to lockout approved by the laser safety officer. See <a href="#">Chapter 10, "Laser Safety"</a> .	
Ionizing radiation	<p>Any work that involves ionizing radiation must be performed in accordance with requirements set forth in <a href="#">Chapter 9, "Radiological Safety"</a>.</p> <p>For equipment that could potentially expose a worker to ionizing radiation above an administrative control level in a short time period during servicing and maintenance on that equipment, the use of lockout should be considered as part of the work planning phase.</p> <p>Work that requires breaching accelerator-related vacuum systems requires lockout of the RF source(s) in accordance with the requirements of this chapter.</p> <p>Call the Radiation Protection Department (ext. 4299) for information on areas controlled for radiological purposes, dosimetry, training, and work planning.</p>	
<p><i>1. Double valve isolation is required when the operating temperature exceeds 200°F or the operating pressure exceeds 500 psig.</i></p>		

## 2.1 Energy Types: Additional Information and References

### 2.1.1 Electrical

For more information, see [Chapter 8, “Electrical Safety”](#).

### 2.1.2 Thermal

Thermal energy – what we experience as heat or cold – is commonly produced by mechanical devices (combustion and/or friction), electrical resistance, and chemical reactions (or changes of state). Thermal energy can be controlled and/or dissipated.

Burns can occur due to both heat and cold, and the severity of a burn depends on temperature and duration or contact. The threshold for injury due to contact with hot liquids (which can cause burns or scalding) is 120°F (52°C). The threshold for injury to tissues due to cold is slightly below freezing (27°F [-3°C]). All cryogenic liquids present a cryogenic burn hazard.

Contact hazards with hot or cold surfaces are typically controlled with insulation, personal protective equipment (PPE), and/or time sufficient to allow cooling or warming.

### 2.1.3 Kinetic

Kinetic energy is the extra energy an object possesses due to its motion (for example, rotating gears, fans, fan belts, pulleys, flywheels, and rolling or pressing components). Setting an object into motion requires that the object be accelerated to attain motion, and this energy, if hazardous, must be dissipated. No threshold is proposed for kinetic energy; each situation must be evaluated.

### 2.1.4 Potential

Potential energy can be thought of as the energy stored within a physical system. Objects at an elevated level, for instance, contain more potential energy than when they are physically lowered. This also referred to as configurational energy and can be eliminated by lowering an object in a controlled manner. Potential energy is also stored in a compressed spring, which can be released in a controlled manner. No threshold is proposed for potential energy; each situation must be evaluated.

### 2.1.5 Pneumatic and Hydraulic

Pneumatic and hydraulic energy refers to the energy inherent in the pressure that a gas or liquid is under. Pressure is generally expressed as psig (pound-force per square inch gauge), which expresses pressure relative to the surrounding atmosphere. A system can be under positive pressure (greater than atmospheric pressure) or negative pressure (vacuum).

Pneumatic refers to pressurized air or gas, as in compressed air or gas in a compressed gas cylinder. Hydraulic refers to pressurized liquid, such as water in a hose pressurized by a pump. Releasing pneumatic or hydraulic pressure involves identifying the pressure source. If equipment is producing pressure, turn it off. If the pressure is stored, allow it to release or dissipate under controlled conditions.

*Note* This section discusses non-hazardous gases; hazardous gases and liquids at any pressure must be locked out due to their chemical hazards (for example toxic, flammable, reactive).

#### 2.1.5.1 Pneumatic Injury

Provided that skin and eyes are protected and no potential for deadheading (point blank exposure of the jet to bare skin) exists, the pressure required to inflict pneumatic jet injuries to healthy unbroken skin is over 600 psi. Pneumatic sources directed at eyes or ears can cause injuries at significantly lower pressures, depending on the proximity and diameter of the jet. Cal/OSHA ([8 CCR 3301](#)) limits air pressure to 10 psi for blowing dirt, chips or dust from clothing while it is being worn.

*Note*      *The Cal/OSHA limit of 10 psi for using compressed air to clean clothes does not protect from particulates that may be generated by cleaning with pressurized air below 10 psi.*

#### 2.1.5.2 Hydraulic Injury

The pressure required to break intact healthy skin delivered by a hydraulic jet is more than 600 psi. Depending on the diameter of the jet and distance between it and the affected area, much lower pressures are hazardous to eyes, ear drums, and open wounds. Hydraulic injection injuries at distances up to 4 inches between the skin and jet have been recorded.

In larger piping systems, a hazard may be present if the liquid momentum conveyed by water and other liquids is sufficient to knock a worker down.

#### 2.1.5.3 Compressed Air and Water Utility Systems

Nearly every industrial or commercial installation uses utility water or compressed air systems operating at pressures up to 150 psig. Common practice has shown that wearing normal PPE such as coveralls, gloves, and safety glasses provides worker protection and lockout is not normally used or required for servicing and maintenance of these systems.

The need for lockout may be indicated at relatively low pressures in such systems due to secondary factors such as working at elevation, since a sudden release could activate the startle reflex that may cause a fall. Take into account all secondary hazards present in a particular work environment.

#### 2.1.5.4 Compressed Gas Cylinders

Compressed gas cylinders or subsequent valves feeding downstream systems are subject to lockout where 1) the system is being serviced or modified, and 2) the gas is flammable, the gas is toxic, or the delivery pressure with the regulator valve fully open could result in an injury. Lockout does not apply to cylinder installation and removal.

#### 2.1.6 Chemical

There is no threshold below which it can be categorically stated that no hazard exists for a system that may release hazardous chemical solutions at any pressure. This also applies to systems that contain flammable liquids or gases or any gases with a potential of creating a hazardous atmosphere, including gases used for fire suppression systems. Lockout may be necessary based on the hazardous properties of the chemical or to prevent a chemical release that poses environmental consequences. For more information on the properties of hazardous chemicals, see [Chapter 40, "Chemical Lifecycle Management"](#).

#### 2.1.7 Non-ionizing Radiation and Magnetic Fields

Non-ionizing radiation is a form of electromagnetic radiation that can be hazardous at exposure levels above the specified maximum permissible exposure (MPE) levels even though it does not cause ionization of molecules. Non-ionizing radiation includes high intensity visible and invisible light (ultraviolet and infrared) sources, microwaves, radiofrequency waves, and magnetic fields.

Where non-ionizing radiation sources exceed their respective MPE, the hazard must be evaluated. Service and maintenance on radiofrequency and microwave systems generally need hazardous energy control and lockout when exposure above the MPE is possible. For more information refer to [Chapter 50, “Non-ionizing Radiation”](#).

Refer to ESH Manual [Chapter 50 Non-Ionizing Radiation](#) for magnetic field exposure limits.

## 2.1.8 Lasers

Where workers could be exposed to beams from Class 3B and Class 4 lasers while performing service or maintenance on those systems, procedures to achieve control of hazardous energy must be evaluated, including the possible need for lockout. Lockout may apply in such situations as

- Connecting or disconnecting fiber terminations if the fiber transmits Class 3B or Class 4 laser radiation
- Maintenance or service work on equipment associated with a laser transport line

Laser SOPs are developed in compliance with [ANSI Z136.1](#) to address potential hazards associated with service and maintenance during normal production operations using alternative energy controls. For example, in cases where the beam cannot be shut down for maintenance, but instead will be controlled using electromagnetically- or pneumatically-controlled shutters, an effective beam stop bolted in place and tagged LASER SAFETY DEVICE – DO NOT REMOVE would provide additional protection and meet the intent of the lockout requirements. Refer to [Chapter 10, “Laser Safety”](#).

Personal protective eyewear is required when laser personnel work in a nominal hazard zone where laser radiation may be present above the MPE.

## 2.1.9 Ionizing Radiation

When the potential exists for a worker to exceed an administrative control level in a short time period, consider the use of lockout as part of the work planning phase. For more information see [Chapter 9, “Radiological Safety”](#).

Lockout may apply:

- To prevent external radiation exposure during service or maintenance of radiation-generating devices
- To prevent external radiation exposure during use of exposure systems with sealed sources having pneumatic or mechanical transport systems

## 2.2 Potentially Hazardous Energies in Combination

The following partial list of possible dangerous combinations of hazardous energies is meant to illustrate the types of configurations to watch for; many other combinations of energies may be hazardous.

- **Water and electricity.** Consider the potential for shock or arc flash hazard when working on water lines over electrical components or when working on electrical systems in a wet location.
- **Compressed air and toxic materials.** Consider results of inadvertent activation (will it generate toxic or radioactive dusts or aerosols that create contamination or personal exposure?)
- **Work on a ladder and unexpected energy or noise.** Consider the location of overhead water or air lines when placing the ladder; consider the effect of unexpected impact of air or water or elevated noise level from release of compressed air. (A startled worker may fall or drop tools.)
- **Inert gas in a confined space.** Consider asphyxiation hazards in a work location with poor or no ventilation; shut the gas source off and lock it out avoids oxygen depletion.

- **Magnetic fields and metal.** Consider that ferrous tools may be propelled by strong magnetic fields.
- **Pneumatic and thermal.** Consider thermal and pneumatic hazards near live steam or pressure relief valves.

### 3 Forms

The following forms and systems are required by this procedure:

- None

### 4 Recordkeeping

The following recordkeeping requirements apply for this procedure:

- None

### 5 References

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

- [Chapter 51, “Control of Hazardous Energy”](#)
- [Chapter 8, “Electrical Safety”](#)
- [Chapter 9, “Radiological Safety”](#)
- [Chapter 10, “Laser Safety”](#)
- [Chapter 14, “Pressure Systems”](#)
- [Chapter 40, “Chemical Lifecycle Management”](#)
- [Chapter 50, “Non-ionizing Radiation”](#)

#### Other Documents

- Title 8, *California Code of Regulations*, “Industrial Relations”, Division 1, “Department of Industrial Relations”, Chapter 4, “Division of Industrial Safety”, Subchapter 7, “General Industry Safety Orders”, Group 2, “Safe Practices and Personal Protection”, Article 7, “Miscellaneous Safe Practices”, Section 3301, “Use of Compressed Air or Gases” ([8 CCR 3301](#))
- American National Standards Institute (ANSI) Z136.1, “Safe Use of Lasers” ([ANSI Z136.1](#))