NATIONAL ACCELERATOR LABORATORY

ENVIRONMENT, SAFETY & HEALTH DIVISION

Chapter 10: Laser Safety

Class 3B and Class 4 Laser CoHE Requirements

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1 Purpose

The purpose of these requirements is to prevent the unexpected energization or startup of machines or equipment, or release of stored energy. They cover *control of hazardous energy (CoHE)* for Class 3B and Class 4 lasers. They apply to workers, *system laser safety officers (SLSOs)*, and the *laser safety officer (LSO)*.

2 Requirements

2.1 Overview

Class 3B and Class 4 laser radiation is considered hazardous energy because of the potential for serious eye injury. Therefore careful consideration of CoHE is needed to protect workers. Key CoHE practices are especially important to follow if laser eyewear protection is not being worn when working – workers need very good assurance that laser hazards have been adequately disabled and controlled.

There are three general approaches to meeting SLAC's CoHE program requirements:

1. **Lockout/tagout (LOTO).** When *service* or *maintenance* is performed on equipment, de-energization of the equipment is the preferred method for achieving CoHE. When this is done, LOTO requirements apply (see Chapter 51, "Control of Hazardous Energy").
2. **Alternative energy controls.** If service or maintenance on a laser is being done and LOTO is not applied, then alternative energy control methods must be used. Such methods must utilize appropriate *machine guards* (for example, laser *master key* and *laser safety shutters*). This is the method used to satisfy CoHE requirements for most laser service and maintenance. It is subject to the requirements noted in Section 2.3.
3. **Administrative lock and tag.** If a laser system needs to be shut down or secured (for example securing a *barrier* to ensure Class 1 operation) for purposes of configurational or operational control, not for the personal protection of the person applying the lock, then an administrative lock and tag procedure may be used (see Chapter 51, "Control of Hazardous Energy").

Routine daily tasks by *qualified laser operators (QLOs)* and *laser controlled area (LCA) workers* in laser facilities are usually considered *normal operations* with energized or partially-energized laser equipment. Laser alignment and optics work by QLOs, including creating new beam paths and replacing damaged optics, are generally considered tasks that are "routine, repetitive and integral to normal operations" for laser workers.

Service and maintenance work by QLOs often require energized or partially energized (that is, enabled) laser beams, in which case laser eyewear protection is used in addition to other alternative energy controls to prevent an accidental exposure.

2.2 Energy Isolating Devices

SLAC's CoHE program requires equipment to have *energy isolating device(s)* with appropriate LOTO capability. For laser systems this includes an easily verifiable closed position for a lockable beam block if a beam block is used. *(Note it may not be necessary for a laser safety shutter to satisfy a LOTO capability requirement if cord-and-plug control can be used to disable the laser hazard or if an alternating current [a.c.] circuit breaker can be locked out.)*

If a laser safety shutter or a laser beam block is used not as a machine guard, but as an energy isolating device to protect a worker performing a non-routine maintenance or service task from an unexpected laser hazard, then it must satisfy LOTO requirements. An equipment-specific lockout procedure (ELP) will need to be developed and approved (unless cord-and-plug control is applicable). The ELP will need to include a description of the location and operation of the energy isolating device. The ELP must also describe how *zero energy verification (or energy isolation)* is done. (See Chapter 51, "Control of Hazardous Energy".)

2.3 Alternative Energy Controls

Alternative energy controls must use the necessary combination of *engineering controls* (machine guards such as safety shutters, interlocks, and key control), warning and alert systems, *administrative controls*, training, and *personal protective equipment (PPE)* such as laser eyewear to achieve effective CoHE protection for workers. These controls must be documented in the *lab-specific standard operation procedure (SOP)* or *job safety analysis (JSA)*, with review and approval by the LSO.

The LSS generally provides most of the engineering controls required when alternative energy controls are used for CoHE. Additional LSS requirements to those described in this document can be found in the Laser Safety Systems Technical Basis Document.

2.3.1 Master Keys

Each Class 3B and Class 4 laser requires an associated master key. The master key must be removable and the laser must not be operable when the key is removed.

2.3.2 Laser Safety Shutters and Safety Beam Blocks

Laser safety shutters and safety beam blocks are remotely (for safety shutters) or manually (for safety beam blocks) controlled and can be inserted to function as a machine guard, or sometimes as an energy isolating device in a LOTO procedure. Safety shutters are often used to disable a laser hazard when the engineered *laser safety system (LSS)* detects a fault condition (for example, LCA access violation or *Class 1 enclosure* cover removal). Safety shutters and interlocked safety beam blocks are sometimes used as part of a Class 1 enclosure; in Class 1 operation mode laser eyewear protection is not required.

Note *Safety shutters and safety beam blocks with IN position sensors provide a higher level of engineering control when they are interfaced to an engineered LSS that can disable laser*

hazards when certain interlock requirements (for example, for LCA access control, LCA operation mode or a Class 1 enclosure) are not met.

The following requirements apply to laser safety shutters and safety beam blocks:

- Each independent laser system should have an associated safety shutter or a dedicated safety beam block (safety shutters are recommended for this). When used as such, shutters or blocks must be placed directly at the source laser output aperture or as close as practical. Safety enclosures associated with them should be as small as practical to limit how often the shutter may be accessible.
- Safety shutters or dedicated safety beam blocks should be used at the input to devices that can generate other wavelength hazards (for example, harmonics crystals, optical parametric amplifiers [OPAs], or OPCPA [optical parametric chirped-pulse amplifiers [OPCPAs]). Safety shutters are recommended for this and should only be enabled when needed for a particular Class 4 operation mode.
- Safety shutters and safety beam blocks must have an IN readback sensor with an associated display signal available for monitoring by laser personnel.
- Safety shutters should have independent readback sensors (and associated displays) for the IN and OUT positions.
- Safety shutters should have independent control and readback (for example, to assist with a LOTO or administrative lock and tag procedure).
- Safety shutters must close when control signals or power are deactivated or removed.
- When there is an inconsistency between the requested state and the (IN or OUT) position sensors, the laser safety system should give an alarm warning and, if possible, inhibit the laser upstream of the safety shutter or safety beam block.
- Safety shutters' manufacturing information must be described in the lab-specific SOP or JSA, including an evaluation of their ability to withstand the maximum laser irradiance.
- Safety shutters and safety beam blocks must be labeled LASER SAFETY DEVICE. Safety labels should be placed over the securing bolts for safety shutters and indicate that SLSO approval is required to move or modify. SLSOs should also consider use of a special tool, administrative lock, or interlock to address safety configuration control for safety shutters.
- Correct safety shutter (and, if applicable, interlocked safety beam block) operation and interlock functionality must be tested at least once per year as part of a laser safety certification procedure.
- Control shutters should not share common hardware, such as a controller interface chassis, with safety shutters and should not be controlled by the LSS. *(Note control shutters are used to enable beam paths for operational needs rather than safety.)*

2.3.3 Activation Warning System Requirements

An audible or visual emission indicator is required to indicate the possible presence of an accessible Class 3B or Class 4 laser beam. An appropriate audible or visual indicator is also required just before laser emission to allow actions to avoid exposure. Laser safety shutters usually require an audible warning 10 to 15 seconds before opening; this must be described in the lab-specific SOP or JSA.

2.3.4 Requirements for Laser Safety System Interlocks

Interlocks for access doors, protective covers, service access panels, and enclosures must be open normally. Doors and covers must be closed to satisfy (close) the interlocks.

Power failure to an interlock circuit or removing an interlock connector must cause the laser system to go into, or remain in, a safe state by closing shutters or disabling power.

All interlock faults must be latching.

2.3.5 LCA Search Required Before Enabling Laser Hazards

Before turning on the beam and making it accessible, the responsible QLO must

- Search the LCA to ensure that only qualified laser personnel are present and that all wear appropriate protective eyewear
- Warn personnel present of the laser hazard being enabled

This procedure must be described in the lab-specific SOP or JSA.

2.4 Laser Transport Safety Shutters

When a laser safety shutter is used as a machine guard (for example, as part of a Class 1 enclosure or as a beam block) to prevent transport of a Class 3B or Class 4 laser beam to an area that has unrestricted access to *affected workers* (personnel other than QLOs, LCA workers, laser service subcontractors, and the LSO), the following requirements apply:

- Two redundant transport shutters must be installed to act as an effective machine guard.
- A shutter acceptance test must be done to verify the mechanical integrity of the shutter system to be an effective machine guard, and the LSO must review and approve the test (a template for this test is available on the Laser Safety Program Site).
- An illuminated display sign must be used to communicate the laser hazard status (for example, Laser Off mode or Class 1 mode).
- Affected workers who rely on the transport shutters as a machine guard must receive appropriate training information about the laser hazard controls (in some cases the area hazard analysis document may be used for this).
- Work by affected workers must be outside the envelope of the LSS components.
- Requests by affected workers to apply LOTO for their work need to be respected and accommodated.

2.5 Zero Energy Verification

If the LSS is being used as a machine guard to disable the laser hazard so that laser eyewear protection can be removed, a *zero energy (or energy isolation) verification* must be done before removal of the eyewear. This may be done by verifying the IN status of a laser safety shutter or by using an appropriate laser beam power meter or diagnostic. Zero energy verification procedures should be described in the SOP or JSA.

2.6 Service and Maintenance Procedures

The lab-specific SOP or JSA must define *service* and *maintenance* work. Examples include work done by service subcontractors and work done when interlocked protective covers or service access panels are removed.

- A NOTICE sign must be placed at the LCA entry when service subcontractor work is in progress.
- When an interlocked cover or service access panel is removed, the LSS must be evaluated for any changes in its normal functions (for example to prevent laser hazards by inserting shutters and to provide an activation warning system with emission delay). If some of the normal LSS functions are absent, additional controls may be needed to provide equivalent protection as during normal operation.
- The SLSO is responsible to identify if any work activity may need a CCF or LOTO and will then consult with the LSO to make a determination.

2.7 Equipment Custodian Requirements

The lab-specific SOP, JSA, or Laser Safety Program Site must describe who is responsible for the laser equipment.

2.8 Training

Workers who rely on alternative energy controls to provide effective CoHE protection against an accidental laser exposure must receive appropriate training from the SLSO or designee. For QLOs and LCA workers this is done as part of their OJT and site-specific training.

In addition, the SLSO is required to take one of the following courses:

- ESH Course 157, Control of Hazardous Energy (ESH Course 157)
- ESH Course 136, Control of Hazardous Energy – Affected Employee (ESH Course 136)

2.9 Fiber Optics Connectors

Class 3B and Class 4 laser sources to the fiber transport cables must be blocked or disabled before connecting or disconnecting the fiber.

If a fiber transport cable is disconnected and the laser source enabled, an LCA must be established and protective eyewear worn.

If the fiber terminations are to be directly inspected, then the laser hazard must be disabled – protective eyewear may never be relied on to permit direct intrabeam viewing. The QLO performing this task may disable the laser hazard by removing the laser enabling key (master key) if he or she is in control of this key; if this cannot be done, then LOTO must be used unless cord-and-plug control can be used. Whatever method is used to disable the laser hazard, zero energy (or energy isolation) verification must also be done.

Note *Additional engineering and equipment label requirements can be found in Laser Safety: Class 3B and Class 4 Laser Operation Requirements.*

2.10 Affected Worker

Affected workers are personnel other than QLOs, LCA workers, laser service subcontractors, or the LSO who may need to perform work in a facility that houses Class 3B or Class 4 lasers.

- Work should be done in Laser Off mode with the master key removed to disable laser hazards as part of an administrative configuration control or administrative lock and tag control. Such work can be done without requiring LOTO if the workers are not doing service or maintenance on laser equipment and are adequately informed of how the lasers are disabled.
- Work may be done in Laser On mode (may be Class 1 or Class 4), if all the following requirements are satisfied:
  - Workers are not doing service or maintenance on equipment associated with the LSS.
  - Work should be done in Class 1 mode rather than Class 4 mode.
  - Laser visitor requirements are satisfied as described in Laser Safety: Laser Controlled Area Visitor Requirements.
  - While LOTO is not generally required, if affected workers request to apply LOTO for their work to satisfy CoHE, then such requests need to be respected and accommodated.

3 Forms

The following forms and systems are required by these requirements:

- Shutter Acceptance Test Form (available on the Laser Safety Program Site [SharePoint])
- Fiber Optic Connector Label (available on the Laser Safety Program Site [SharePoint])

4 Recordkeeping

The following recordkeeping requirements apply for these requirements:

- Transport shutter acceptance test documents will be maintained by the SLSO.

5 References

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

- Chapter 10, "Laser Safety"
  - Laser Safety: Class 3B and Class 4 Laser Operation Requirements (SLAC-I-730-0A05S-004)
  - Laser Safety Systems Technical Basis Document (SLAC-I-730-0A05Z-001)
  - Laser Safety: Class 3B and Class 4 Laser Eyewear Protection Requirements (SLAC-I-730-0A05S-007)
  - Laser Safety: Laser Controlled Area Visitor Requirements (SLAC-I-730-0A05S-011)
  - Laser Safety Program Site (SharePoint)

- Chapter 51, "Control of Hazardous Energy"

Other SLAC Documents

- ESH Course 157, Control of Hazardous Energy (ESH Course 157)
- ESH Course 136, Control of Hazardous Energy – Affected Employee (ESH Course 136)