Chapter 10: Laser Safety

General Requirements

1 Purpose

The purpose of these requirements is to ensure applicable controls are in place for each class of laser. They cover classifying, labeling, and using all classes of lasers. They apply to workers using lasers, system laser safety officers (SLSOs), laser laboratory program managers, line management, and the laser safety officer (LSO).

2 Requirements

Laser safety requirements depend on three factors:

1. The laser classification: each laser is assigned a classification (Class 1, Class 2, Class 3R, Class 3B, or Class 4) based on the level of its accessible radiation and the associated ability of the laser beam to cause injury to the eye or skin. For example, a Class 4 laser is capable of causing greater injury than a Class 3B laser.

2. The environment in which the laser is used, including access to the beam path (considering such factors as enclosures and barriers).

3. The personnel who may use or be exposed to laser radiation.

2.1 Classification

Lasers are classified according to their accessible radiation during normal operation. A commercial laser purchased with a manufacturer-provided hazard classification that is in conformance with the Federal Laser Product Performance Standard (FLPPS, 21 CFR 1040.10 and 21 CFR 1040.11) fulfills all classification requirements.

Lasers fabricated for research and without manufacturer’s assurance of FLPPS compliance must be classified prior to operation.

The LSO will classify lasers and laser systems when the classification is not provided, the classification is not in accordance with the FLPPS, or the intended use is different from the use recommended by the manufacturer, or engineering control measures are added, deleted, or modified. Laser classes are given in Table 1.
### Table 1 Laser Classes and Hazards

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<th>Class</th>
<th>Hazard</th>
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| **Class 1** | - Incapable of producing damaging radiation levels  
- May have an accessible laser beam at very low intensity, or may be a fully enclosed laser with no accessible radiation  
- Exempt from any administrative or PPE control measure requirements |
| **Class 2** | - Emits visible radiation at wavelengths between 400–700 nm  
- Eye aversion response (blinking or looking away) provides adequate protection, but eye injury is possible if there is an intentional prolonged exposure. The eye aversion response time is assumed to be 0.25 seconds.  
- Maximum average power for continuous wave (cw) lasers is 1 mW  
- Can present a startle hazard and may cause temporary flash-blindness, after images and glare responses; thus some controls are needed to prevent an accidental exposure |
| **Class 3R**  
(previously called 3a) | - Emitted radiation may be visible or invisible  
- Visible laser radiation is greater intensity than Class 2, but must be within a factor 5 of the Class 2 accessible emission limit (maximum average power for cw lasers is 5 mW). Invisible laser radiation is greater intensity than Class 1, but must be within a factor 5 of the Class 1 accessible emission limit.  
- Generally not considered a significant hazard for accidental viewing, but is a potential hazard for direct or specular reflection viewing  
- Can present a startle hazard and may cause temporary flash-blindness, after images and glare responses; thus some controls are needed to prevent accidental exposure |
| **Class 3B**  
(previously called 3b) | - Emitted radiation has intensity greater than Class 3R. Maximum average power is less than 500 mW (can be lower for pulsed lasers).  
- Eye hazard for direct or specular reflection viewing; there are associated laser eyewear protection requirements. |
| **Class 4** | - Emitted radiation has intensity greater than Class 3B  
- Hazard to eye or skin from direct beam; there are associated laser eyewear protection requirements  
- Diffuse reflections may be hazardous  
- Potential for fire hazard from laser intensity exceeding combustibility thresholds of some materials  
- Laser-target interactions may produce laser-generated air contaminants, and hazardous plasma radiation at very high intensities |
2.2 Control Hierarchy

Laser hazards are controlled with a combination of engineering and administrative controls and personal protective equipment (PPE). Engineering controls are given first priority. If possible, they are used to eliminate the laser hazard by fully enclosing the laser beam. Class 3B and Class 4 laser operation requires significant engineering, administrative, and PPE controls, in particular for use of laser eyewear protection. There must be sufficient redundancy of controls to ensure safe laser operations with minimal risk for injury.

2.3 Alternate Controls

Upon review and approval by the LSO, the engineering and administrative control measures specified in this chapter may be replaced by procedural, administrative, or other alternate engineering controls that provide equivalent protection. If alternate control measures are instituted, then those personnel directly affected by the measures must be provided the appropriate laser safety and operational training.

2.4 Operation Modes

Laser operation will be in one of three operation modes:

1. Normal. The laser is operating over the full range of its intended functions. This can include adjustments and alignment work, which are normal activities for qualified laser operators (QLOs). A laser controlled area (LCA) may define more than one normal operation mode to indicate which laser hazards are enabled and what the corresponding laser eyewear protection requirement is, for example Laser Off, Class 1, and Class 4.

2. Maintenance. Adjustments or procedures are performed to maintain or re-establish optimal performance of the laser system. Usually this operation mode means that the configuration of a laser safety barrier is changed, which may affect laser eyewear protection requirements or the functionality of interlock systems.

3. Service. The performance of procedures, typically defined as repair, to bring the laser or laser system or laser product back to normal operational status. For example, work by service subcontractors will be in service mode and an area NOTICE sign will be used to signify this.

2.5 Unattended Operation

Only Class 1 lasers or laser systems will be used for unattended operation in unsupervised areas without the implementation of additional control measure requirements.
2.6 Exposure Control

The following controls are recommended for all laser classes above Class 1 to minimize the risk from potential exposure to laser beams:

- Use the minimum laser radiation required for the application.
- Avoid eye and skin exposure and direct viewing of the laser beam; maintain the beam at a level other than the eye level of a person sitting or standing.
- Limit potential exposure levels to as far below the maximum permissible exposure (MPE) values as is practical (values for the MPE are below known hazardous levels and can be obtained from the LSO or ANSI Z136.1).

2.7 Protective Housing

A laser must be contained in its appropriate protective housing to reduce potential exposure. The aperture through which the useful beam is emitted is not part of the protective housing. Special safety procedures may be required when protective housings are removed.

The protective housing must

- Limit the maximum accessible laser radiation to a level that defines the classification
- Have classification labels affixed on a conspicuous part of the laser housing
- Limit access to other associated radiant energy emissions and to electrical hazards associated with components and terminals
- Have interlocks to disable the laser operation if the cover is removed (these interlocks may be defeatable for service work) or be secured and have an appropriate warning label, which states hazards and additional controls needed if cover is removed

2.8 Warning Signs and Labels

- All lasers must have labels on the protective housing that specify their classification.
- All lasers with an aperture output must have an associated aperture label.
- All lasers with defeatable interlocks must have an associated warning label.
- Long distance (>3 meters) beam conduits that contain beams operating above Class 1 levels must have labels at appropriate intervals (approximately 3 meters) to provide warning of the relative hazards of laser radiation contained within the conduit. Note: this requirement does not apply to fiber optics cables used in optical fiber communications systems.

Templates for labels and signs are available on the Laser Safety SharePoint Site.
2.9 Work Planning and Control

Laser operations must comply with SLAC work planning and control (WPC) requirements (see Chapter 2, “Work Planning and Control”). WPC requirements for laser safety when working with Class 3B and Class 4 lasers include the following:

- Work by QLOs and laser controlled area workers is considered yellow work. Authorization and release for this work is done via Laser Safety: Qualified Laser Operator Approval Form or a Laser Safety: Laser Controlled Area Worker Approval Form, respectively. Such work performed by service subcontractors is considered red work and is authorized and released following Laser Safety: Laser Service Subcontractor Work Planning and Control Procedure.

- A laser safety contract, SOP, or JSA is used to describe hazards and controls associated with this laser work. Laser work may only begin after these documents and the laser laboratory itself have been approved.

- Pre-job briefings must be held as appropriate, and are recommended for new tasks, unfamiliar or infrequently performed tasks, significant configuration changes, or returning system to operation following a downtime or power outage.

- Additional requirements exist when laser work is performed by service subcontractors (see Laser Safety: Laser Service Subcontractor Work Planning and Control Procedure).

For details, see Laser Safety: Class 3B and Class 4 Laser Operation Requirements.

3 Forms

The following are forms required by these requirements:

- None

4 Recordkeeping

The following recordkeeping requirements apply for these requirements:

- None

5 References

SLAC Environment, Safety, and Health Manual (SLAC-I-720-0A29Z-001)
Chapter 10, “Laser Safety”
- Laser Safety: Laser Pointer Requirements (SLAC-I-730-0A05S-010)
- Laser Safety: Class 2 and Class 3R Laser Operation Requirements (SLAC-I-730-0A05S-003)
- Laser Safety: Class 3B and Class 4 Laser Operation Requirements (SLAC-I-730-0A05S-004)
- Laser Safety: Class 3B and Class 4 UV Laser Operation Requirements (SLAC-I-730-0A05S-012)
- Laser Safety: Qualified Laser Operator Approval Form (SLAC-I-730-0A05J-007)
- Laser Safety: Laser Controlled Area Worker Approval Form (SLAC-I-730-0A05J-008)

Chapter 2, “Work Planning and Control”

Other SLAC Documents
- Laser Safety SharePoint Site

Other Documents
  - Section 1040.10, “Laser Products” (21 CFR 1040.10)
  - Section 1040.11, “Specific Purpose Laser Products” (21 CFR 1040.11)