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A GUIDANCE DOCUMENT FOR LASER SYSTEM SUPERVISORS[1]

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Abstract

The laser safety program at the SLAC National Accelerator Laboratory has produced a document, "Guidance for SLAC System Laser Safety Officers (SLSOs)." SLSO is the SLAC designation for a laser system supervisor with responsibility for laser operations and laser safety in a specific laser lab. The 27-page guidance document covers a wide range of topics to ensure safe and efficient laser operations. Topics include:

- roles and responsibilities, including lab management and matrixed supervision;
- laser laboratory design and construction, and hazard control hierarchy;
- engineered safety interlock system requirements: including design reviews, documentation and certifications;
- laser operations, including: procedures, safety documentation, online tools, configuration control, operation modes, eyewear requirements, and safety inspections;
- training of laser personnel;
- service subcontractor visits; and
- SLAC requirements that impact laser operations, including: project review, work planning and control, conduct of engineering, and electrical safety.

The guidance document was produced by SLAC's Deputy LSO with assistance from the LSO, a Laser Safety Committee member, a laser system supervisor SLSO, and a laser operations engineer. The report was released in August 2014. It is used together with SLAC's "Laser Supervisor Safety" training course to provide resources and training to support and augment policy requirements in the "Laser Safety" chapter of SLAC's ES&H (Environment, Safety and Health) Manual.

Overview

Laser system supervisors perform critical tasks necessary to achieve safe and efficient laboratory operations. They establish a sound safety culture, set performance expectations, and provide training, documentation and oversight. In the role of mentor they model good practices, and are required to correct bad ones when brought to their attention. At SLAC, each Laser Controlled Area (LCA) for Class 3B and Class 4 lasers has a designated SLSO who has line management and day-to-day responsibility for safe laser operations. SLSOs author the Standard Operating Procedures (SOP) document for their LCA, provide site-specific On-the-Job Training (OJT), and are responsible for certifying that engineering controls function correctly.

In addition to laser safety requirements, the SLSO must address other program requirements which affect laser operations. Figure 1 depicts how different chapters in the SLAC ES&H Manual [1] impact laser laboratory operations.

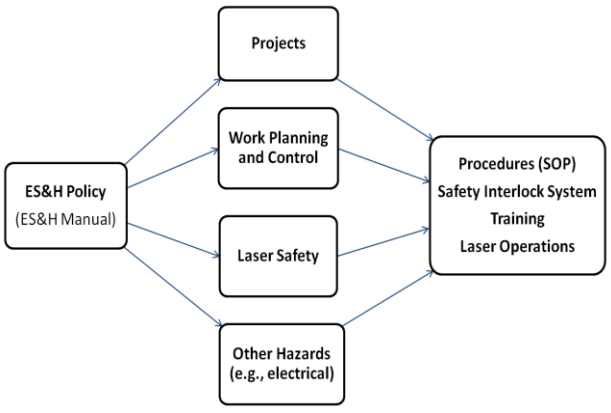

Figure 1: Flow down of safety policy requirements as specified in the SLAC ES&H Manual.

[1]Presented at 2015 International Laser Safety Conference, Albuquerque, NM; www.lia.org/conferences/ilsc

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The *Guidelines for System Laser Safety Officers* document includes the following seven chapters and an Appendix as described in the following sections:

1. SLSO: Roles, Responsibilities and Resources
2. Laboratory Construction and Hazard Control Hierarchy
3. Safety Interlock Systems
4. Laboratory Operations
5. Laser Personnel and Training
6. Laboratory Documentation
7. Service Subcontractors

Appendix: References, Resources and Acronyms

1. The SLSO at SLAC: Roles, Responsibilities and Resources

Chapter 1 covers SLSO safety oversight responsibilities for laser equipment and personnel operations in their assigned LCA. In this capacity the SLSO is responsible for the *SOP* and other laser safety documents, including training and certification documents and *Configuration Control Forms*. The SLSO makes frequent decisions pertaining to pre-job briefings, the need for additional safety controls and documents, and when to contact the LSO for further consultation. SLAC management views SLSO personnel as critical to achieving safe and efficient laser operations to further SLAC's science mission.

SLSOs can ensure their LCA is well managed by:

- Assuring good lab configuration, available equipment, procedures and Personal Protective Equipment (PPE);
- Assuring good housekeeping;
- Maintaining good documentation records; and
- Maintaining good signage for lab procedures and safety requirements, while taking care to avoid cluttered or excessive signage.

SLSOs must manage their LCA to make it easy for workers to meet expectations and comply with safety requirements.

Other topics described in Chapter 1 cover:

i. Matrixed Supervision. SLSOs serve as functional supervisors for personnel performing laser-related work in their LCA but may not be their direct administrative supervisor. Hence there is a shared, or matrixed, supervision responsibility.

ii. Management Walk-throughs. SLAC requires functional and administrative supervisors to perform periodic walk-throughs of work areas. The goal of each walk-through is to observe and discuss work, procedures and safe practices. Deficiencies, undesirable practices and inappropriate behaviours need to be identified and addressed. Positive behaviour and good practices should also be recognized and encouraged.

iii. Designating an Acting SLSO. When the SLSO is away from SLAC for travel or vacation an Acting SLSO must be designated.

iv. SLAC Resources. These include ES&H safety coordinators, building and area managers; LSO and Deputy LSO and Laser Safety Committee members; and Laser Science & Technology Department members.

2. Laboratory Construction and Hazard Control Hierarchy

Chapter 2 provides guidelines on how to establish and maintain a laser laboratory at SLAC. When new construction or modifications to an existing laboratory are planned, a risk analysis is required. Depending on the scope of the work, a determination needs to be made whether the work is considered an *activity* or a *project*. A combination of engineering controls, administrative controls, and PPE are used to mitigate hazards. Engineering controls must be given priority.

Projects such as construction of a new laser laboratory or major renovation to an existing laboratory require a project manager, design review by the Laser Safety Committee and potentially review of one or more of the following: earthquake, fire and life safety, ionizing radiation, electrical, chemical, other non-beam hazards, and environmental impact. SLAC project requirements include:

- Consultation with ES&H Coordinators and Subject Matter Experts,
- Project reviews for safety and engineering
- Work Planning and Control (WPC)
- Documentation
- Acceptance and certification tests.

Similar to projects, *activities* are subject to WPC requirements. Examples of *activities* include adding a new laser or wavelength capability. In this case the SLSO notifies the LSO of anticipated configuration changes and, depending on safety implications, consults with the Directorate ES&H Coordinator, modifies the *SOP* or issues a *Job Safety Analysis* (*JSA*) document to supplement the *SOP* description of laser hazards and controls.

Notes:

- Projects and activities must abide by the *SLAC Conduct of Engineering* Policy.
- All electrical equipment must have an *Electrical Equipment Inspection Program*

certification unless it is certified by a Nationally Recognized Testing Laboratory (NRTL) such as UL.

Topics described in Chapter 2 include:

i. Laboratory Design. When designing a new laser lab, SLSOs and project personnel should begin by visiting existing labs. The SLSO then consults with ES&H coordinators, the LSO and the responsible engineer for design of the Laser Safety Interlock System. Appropriate laser safety, engineering and other project reviews are scheduled.

ii. Hazard Control Hierarchy. Hazard mitigation is based on a hierarchy of engineered safeguards, administrative controls and procedures, and PPE. Engineering controls are designed to physically separate the laser beam from the operator. These include safety shutters, beam blocks, barriers and Class 1 enclosures. Engineering controls must be given first priority as a means to protect personnel against hazardous exposures.

iii. LCA Operation Modes. SLAC employs three primary operation modes: Laser Off, Laser Enclosed (Class 1), and Laser On (Class 4).

iv. Personal Protection Equipment (PPE). Examples of good eyewear storage are provided. Good signage, labelling and organization help ensure that correct eyewear is selected. Requirements for "alignment eyewear" use with reduced optical density from full protection are noted, including the need for documented LSO approval. Special consideration for ultraviolet lasers is needed, including an evaluation for skin PPE and additional barriers or enclosures.

v. Signs and Equipment Labels. The posting of signs and labels is an important aspect of laser lab management. These include signs at the laboratory entrance, signs inside the laboratory and labelling of equipment. Posting certain point-of-use procedures is discussed. Template examples for common signs and labels can be found at the Laser Safety SharePoint site.

vi. Purchasing requirements. All purchase requisitions for Class 3B lasers, Class 4 lasers or laser eyewear require notification of the LSO. Online purchase requisitions ask the requester whether the purchase includes any of these items; an affirmative response will automatically notify the LSO. The requisition should include information regarding the need for onsite service work including installation or warranty work. Additional guidance is given for electrical safety requirements for equipment that does not have a NRTL certification, in particular for flashlamp-pumped lasers.

3. Safety Interlock Systems

Chapter 3 begins with a description of a typical Laser Safety Interlock System (SIS) which provides the following functionality:

- an access control system to limit entry to authorized personnel
- a means to define operation modes (e.g., Laser Off, Class 1, Class 4)
- interlocked barriers (shutters, covers, doors, curtains)
- electronic warning displays at the entryway and inside the LCA

In many labs the SIS includes different Class 4 sub-modes to help define accessible wavelengths and which laser beams are enabled.

A functional description of the SIS must be documented, including logic tables. Usually this is included in the lab's SOP. An example of a simple logic table is shown in Table 1. Depending on application and date of construction, several different laser SIS configurations exist at SLAC.

Topics described in Chapter 3 include:

i. Laser SIS Specifications and Components. A detailed specification must be provided which includes a plan view schematic of the lab with locations shown for the SIS components. Components typically include: Master Key, door interlocks, safety shutters with position readback sensors, power supply remote interlocks, electronic signs, emergency off buttons, and audible and visible warning annunciators.

ii. Initial SIS Acceptance Test. This must be completed and documented prior to LCA operation approval.

iii. Annual Certification and Periodic Oversight. The SIS must be re-certified annually. The SLSO must also continually monitor correct operation of the SIS.

iv. Response to Laser SIS failures. The SLSO is responsible for determining the actions to take, and a checklist is provided. Checklist items include: securing the laser system in a safe state, notifying the LSO, overseeing system repairs or implementation of alternate controls, performing appropriate certification tests, and documenting actions taken.

Table 1: Operation Mode Summary: status of safety shutters, laser power supply enable signals, and warning sign displays when SIS interlocks are satisfied. For each mode, the warning sign display will toggle between the two messages listed to indicate the SIS is functionally operational. Sign displays are also colour coded.

Operation Mode	Safety Shutters	Laser Power Supply Remote Interlocks	Warning Sign Displays
Class 1	Closed and Disabled	Enabled	LASER ENCLOSED - CLASS 1 … GOGGLES NOT REQUIRED (amber)
Class 4	Enabled	Enabled	LASER ON … GOGGLES REQUIRED (red)
Laser Off	Closed and Disabled	Disabled	LASER OFF … NO HAZARD (green)

4. Laboratory Operations

As outlined in Chapter 4, an Approval-to-Operate form is issued for the LCA following completion of several items: approval of the SOP document, acceptance of the Laser SIS and completion of pre-start action items resulting from the LSO inspection. In the event a new wavelength or operational hazard is introduced, review and approval by the LSO is required as well as an update to the laser safety documents (SOP or JSA). Certain changes also require a Configuration Control Form.

Topics described in Chapter 4 include:

i. LSO Approvals and Annual Inspections. Annual operation approval requires an LSO inspection with an associated inspection report that includes action items and recommendations. Action items have associated due dates that should be agreed on between the SLSO and LSO. They should be entered into the SLAC Action Tracking System if they may have a significant delay before completion and are deemed to be significant for improving laser safety.

ii. Configuration Control Forms. These are required when actions are performed that modify the safety configuration or function of a Class 1 enclosure, a laser safety shutter, or a component of the engineered Laser SIS.

iii. Laser Pointers and Alignment Lasers. SLSOs need to ensure that these lasers do not exceed Class 3R limits, are appropriately labelled and that they are from a reputable laser manufacturer. Laser eyewear PPE is not required but some controls are needed to protect against accidental exposure that can present a startle hazard or cause temporary impaired vision. These controls may include barriers, warning signs, and restrictions on unattended operation. Support personnel need to be adequately informed of alignment laser operation so they can avoid accidental exposure.

iv. Laser Disposal. Typically when a laser is identified for disposal the equipment is disabled by removing critical components or cutting the power connection. SLSOs are required to consult with the SLAC Hazardous Waste department or the LBNL reference guide [2] for further instruction and not throw lasers or power supplies into trash bins.

v. SLSO Checklist. A summary of periodic and annual items is provided. Periodic items include laboratory walk-throughs and maintaining up-to-date documentation. Annual items include interlock certification, scheduling the LSO inspection, and providing annual refresher site-specific OJT.

5. Laser Personnel and Training

Chapter 5 describes SLAC qualification of two types of laser personnel: i) Qualified Laser Operators (QLOs) and ii) LCA Workers. Both are required to complete general laser safety training that includes: a 3-hour web-based DOE course, a 90-minute classroom *Lessons Learned* course, a 20-minute baseline medical eye exam, and review of the SLAC ES&H Manual's *Laser Safety* chapter [1]. They must also complete site-specific OJT and review the SOP document(s) for the LCA they are approved to work in. All QLOs must complete an additional hands-on *Laser Alignment Practical* course [3]. SLSOs complete the same requirements as QLOs and additionally complete a 2.5-hour *Laser Supervisor* training course provided by the SLAC LSO and a 90-minute web-based course *Control of Hazardous Energy*.

Topics described in Chapter 5 include:

i. Users and Visiting scientists. These are non-employees that come to SLAC to use technical facilities and participate in

experiments. They are assigned a SLAC Point-of-Contact (POC) who has similar responsibilities as an administrative supervisor. If being qualified as a QLO or LCA Worker, they must complete the same requirements as a SLAC employee.

ii. Students. High school students and those under 18 are not permitted to work in a Class 3B or Class 4 LCA. Undergraduate and graduate students require a period of initial supervision before they can be approved to work unsupervised in an LCA. Special attention for mentoring students is required and guidance for this is given, including: encourage professional behaviour and help build self-confidence, confront negative behaviours and attitudes, build rapport and offer encouragement, and establish performance expectations.

iii. On-the-Job-Training. Formal OJT is defined as employee training at the place of work while he or she is simulating or doing the actual job using the tools, equipment, documents or materials that are required when fully trained. OJT typically includes verbal and written instruction. An experienced employee serves as the instructor and employs key principles of learning (participation, repetition, relevance, transference, and feedback). For laser laboratories, OJT based on the laser laboratory OJT Syllabus must be documented and is required prior to a QLO or LCA Worker being approved to work unescorted. A standard template for an OJT Syllabus is provided that contains four sections: a site-specific orientation checklist, a list of core laser safety practices, a matrix of approved activities, and how to qualify OJT providers.

iv. Visitors. Standard policy requirements for visitors to an LCA are described in the ES&H Manual [1], and any deviations from this are noted in the laboratory SOP. If visitors are permitted during Laser ON Class 4 operation, the visitor policy must be posted at the LCA entryway to facilitate the required policy review between the QLO or LCA Worker escort and the visitor.

v. Communicating Expectations and Corrective Actions. Administrative supervisors and POCs have responsibilities to inform workers of job expectations and requirements, and to provide appropriate coaching. SLSOs, as functional supervisors, have similar responsibilities for these tasks in regard to laser-related work performed by QLOs and LCA Workers in their facility. Occasionally, problems may occur and it is important to address them effectively. In most cases, the SLSO and affected QLO or LCA Worker should be able to discuss and resolve a concern immediately. In some cases, the SLSO may determine that more significant action is needed. When this happens, the SLSO needs to determine appropriate corrective actions in consultation with other people that may include the administrative supervisor or POC, the program manager, the LSO, or Human Resources staff. Any disciplinary action for SLAC employees must involve the Human Resources department.

6. Laboratory Documentation

Chapter 6 provides SLSO guidance on how to maintain up-to-date laboratory records and documentation. The two main repositories for this are a laser safety binder and an associated SharePoint website. Required documents must be available locally at the LCA either in the binder or easily accessible from links at the SharePoint site. Required safety documents include: SOPs and JSAs, Approval-to-Operate forms, Laser SIS certifications, Configuration Control Forms, annual LSO inspection reports, QLO and LCA Worker training records, and a laser inventory.

Each SLAC laser laboratory has an associated SharePoint website where the SLSO can maintain files online. The SharePoint site has two webpages for each laser facility: i) a *Laser Facility Summary* page that provides links to documents and summary information including location, assigned SLSO, expiration date for operation approval and a laser inventory; and ii) a *Document Library* page, for hosting documents that are not available online elsewhere.

7. Service Subcontractors

Chapter 7 outlines the important steps required for the process of bringing a service subcontractor onsite to perform laser work. Service subcontractor work requires specific documentation, approval from SLAC purchasing and the LSO, and a pre-job briefing. This is coordinated and led by the SLSO or a project manager, who has line management responsibility for safety and WPC (*Work Planning and Control*). A buyer from SLAC Purchasing ensures that a valid contract exists to cover the work. The LSO provides oversight and participates in the pre-job briefing.

Appendix: References, Resources and Acronyms

Web links to reference documents and resource information are given in an appendix, including:

- SLAC ES&H Manual chapters on *General Policy and Requirements*, *Work Planning and Control*, *Laser Safety*, and *Management Walk-throughs*
- SLAC Action Tracking System
- SLAC Laser Safety Program SharePoint site with associated webpages including: LCA webpages; laser inventory; checklists, forms and templates; laser safety tools (e.g., shutters, barriers, viewing diagnostics); laser eyewear; and service subcontractor documentation.
- SLAC Conduct of Engineering policy
- SLAC Electrical Equipment Inspection Program
- SLAC Controlled Document Management System
- Regulatory drivers and other standards on which SLAC's laser safety policy is based.

A list of common acronyms is given for easy reference. Some examples are:

- JSA (Job Safety Analysis document)
- LCA (Laser Controlled Area)
- MPE (Maximum Permissible Exposure)
- NHZ (Nominal Hazard Zone)
- NRTL (Nationally Recognized Testing Laboratory)
- OJT (On-the-Job Training)
- PPE (Personal Protection Equipment)
- POC (Point-of-Contact for non-employees)
- QLO (Qualified Laser Operator)
- SOP (Standard Operating Procedures)
- WPC (Work Planning and Control)

Acknowledgements

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References

[1] SLAC ES&H Manual. Chapter 10 is *Laser Safety*.
[2] Lawrence Berkeley National Laboratory's *Laser Reference Guides*. These include a *Laser Lab Design Guide*, a *Laser Operations Reference Guide* and a *Laser Disposal Guide*.
[3] SLAC's *Laser Alignment Practical Tr*aining Course, M. Woods and S. Edstrom, SLAC-PUB-14345, 2011.

Meet the Authors

Jeff Corbett is the Deputy Laser Safety Officer at the SLAC National Accelerator Laboratory. His background is in Electrical Engineering where he earned a PhD in Nuclear Fusion and Plasma Physics from the University of California at Los Angeles. He has worked 23 years at SLAC on accelerator operations, machine design, beam feedback and diagnostic systems utilizing both electron and photon beams. He presently serves as the System Laser Safety Officer for photocathode research facilities at SSRL and the ASTA laboratory at SLAC.

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