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SPLITTING THE SOP INTO GENERAL AND LAB-SPECIFIC DOCUMENTS[1]

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Abstract

The scope and purpose of the *Standard Operating Procedures* (SOP) document for a laser lab is often too broad which results in a lengthy, cumbersome document that is difficult to use. SLAC National Accelerator Laboratory is working to improve SOP documents by splitting them into a "General Laser Laboratory Safety for Laser Workers" (*General SOP*) document and a lab-specific "Standard Operating Procedures and Laser Safety Contract" (*Lab-specific SOP*) document.

Introduction

The philosophy for splitting the SOP into general and lab-specific documents is similar to that for having horizontal and vertical laser safety standards. The general and lab-specific SOPs have minimal overlap and requirements in both apply, though the lab-specific document takes precedence if there is a conflict. Laser workers must be familiar with both the *General SOP* and *Lab-specific SOP* documents.

The *General SOP* document describes hazards and controls that are broadly applicable to Class 3B and Class 4 laser laboratories at SLAC, most of which use a SLAC-built Laser Safety System (LSS). The *General SOP* includes:

i. reference to SLAC policy for controls hierarchy and for work planning and control, and brief overview of these;
ii. controls for common non-beam hazards, in particular for electrical and fire safety;
iii. engineering controls: entryway controls, safety shutters, electronic status indicators, operation modes, master key(s), beam path barriers and enclosures and beam termination;
iv. administrative controls: core safety practices, UV alignment procedures, pre-job briefings, safety configuration control, maintenance and service requirements, and documentation;
v. laser eyewear and skin protection; and
vi. training.

The *Lab-specific SOP* document describes laser hazards and controls specific to the lab, as well as any deviations from the *General SOP*. The laser system supervisor determines which sections of this document are required reading for each laser worker. It includes:

- facility schematic showing laser configuration, safety devices, laser controlled area (LCA), nominal hazard zone (NHZ), and eyewear storage;
- laser hazard parameters and associated optical density (OD) requirements for laser eyewear;
- specifications for approved laser eyewear;
- laser operation modes and associated eyewear requirements;
- procedures to change operation modes or to change eyewear protection;
- specialized procedures;
- interlock functionality, interfaces with other safety systems;
- lab-specific non-beam hazards; and
- lab-specific training.

General SOP Document

The *General SOP* has 14 pages of content. Its table of contents is shown in Figure 1.

Section 1 is an introduction that describes use of the document together with a *Lab-specific SOP*. It gives a brief summary of SLAC policy on utilizing a controls hierarchy with priority for engineering controls and gives a reference for this. It also references SLAC's *Work Planning and Control* program. This section notes that additional laser safety documentation is required for certain laser operations. Additional documents may include:

- a *Job Safety Analysis* (JSA) for new or temporary laser hazards and controls, or for special configurations and procedures;
- a *Configuration Control Form* (CCF) for modifications to the engineered LSS, a safety shutter or a Class 1 enclosure; and
- a service subcontractor JSA with associated pre-job briefing form and approval form.

[1]Presented at 2017 International Laser Safety Conference, Atlanta, GA; www.lia.org/conferences/ilsc

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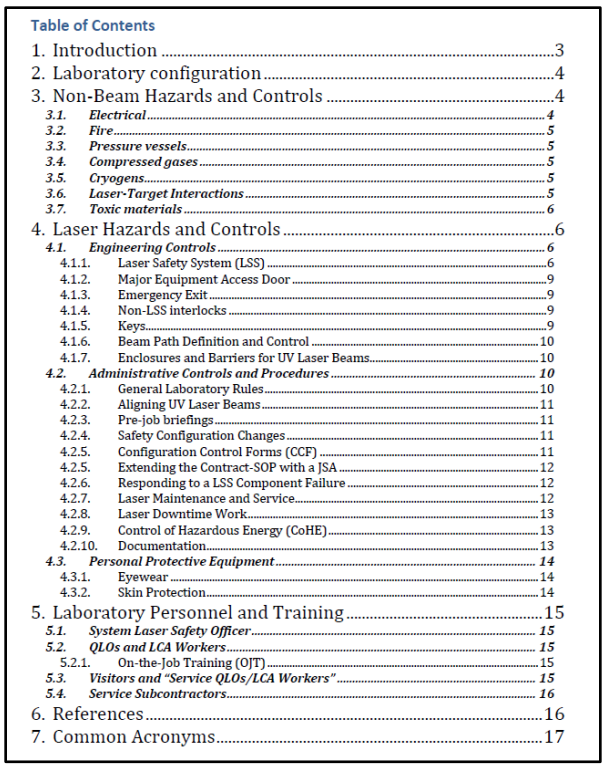

Table of Contents

Figure 1: Table of Contents for the *General SOP*

Section 2 on laboratory configuration is short, noting this is described in the *Lab-specific SOP* which includes a floor plan show showing the laser systems, LSS components, the LCA and the NHZ.

Section 3 on non-beam hazards gives an overview of many hazards that may be present, with an emphasis on electrical and fire safety. The LSO provides assistance in identifying these hazards and recommending appropriate controls for them, but the laser system supervisor and line management for the LCA are responsible for assessing and addressing them. References are given to applicable SLAC policies for the different hazards.

Section 4, laser hazards and controls, notes that *the Lab-specific SOP* describes the laser systems present and has a laser hazard parameter table. There are 3 sub-sections on engineering, administrative and PPE controls.

i. Engineering controls. Different types of these controls are listed in the table of contents in Figure 1. Common implementation features are described, some of which are done to satisfy a SLAC policy requirement [1]. The LSS includes an entryway control system, interlocks, safety shutters, electronic status indicators, visual/audible warnings, emergency off buttons and emergency entry/egress capability. The LSS has an associated master control panel and master key(s). General principles and requirements are described for beam path definition and control. Additional requirements are given to enclose UV laser beam paths to the extent practical, and to implement barriers and beam dumps to minimize potential exposure to diffuse (as well as direct) UV reflections.

ii. Administrative Controls. Many administrative controls are broadly applicable. These are listed in the table of contents in Figure 1 and are briefly described in this section. Foremost is that all laser workers must adhere to the *Core Laser Safety Practices* shown in Figure 2 and wear protective eyewear within the NHZ whenever the LCA is in a LASER ON operation mode. A poster of the core practices is displayed at each LCA – the *General SOP* references this but does not duplicate having it directly in the document.

Core Laser Safety Practices

1	Select proper eyewear; check condition each usage. Ensure all personnel are wearing appropriate laser eyewear.
2	Be knowledgeable of all safety controls + equipment safety features.
3	Remove or cover jewelry, watches, etc. if they may be near beam path.
4	Communicate. Alert others prior to turning on laser, opening shutters, or creating new beam paths.
5	Exclude unnecessary personnel during alignment.
6	Use Class 1 enclosures to eliminate laser hazards when possible. Use table enclosures, barriers and beam tubes when possible.
6	Use indirect methods for viewing the beam such as fluorescent cards, CCD cameras or IR viewers. Implement remote viewing with cameras and monitors.
7	Keep primary and stray beams in horizontal plane below eye level when possible. Avoid bringing eyes near plane in which the laser propagates.
8	Check for and block stray beams. When placing a new optical component in the beam, locate and block all stray reflections before proceeding to next step.
9	Use beam blocks, in particular if inserting or removing optics. Block the beam upstream until beam is needed. Place a block downbeam of optic path being aligned.
10	Special caution is needed when using periscopes, beam-splitting polarizers, and other optics that may generate out-of-plane beams -- secure appropriate beam blocks to contain possible stray beams.
12	Use irises to aid in alignment.
13	Use minimum intensity needed. Use low power alignment lasers when possible.
14	Secure all optics to table. Practice good housekeeping.
15	Perform zero-energy verification when disabling a laser hazard such that laser eyewear can be removed (in accordance with the SOP).

Figure 2: Poster of *Core Laser Safety Practices* that is displayed in each LCA

iii. Personal Protective Equipment (PPE). Eyewear requirements and specifications are given in the *Lab-specific SOP* but this section notes general

requirements for alignment eyewear use and for skin protection for UV laser operation.

The *General SOP* document concludes with a section summarizing different categories (listed in table of contents in Figure 1) of persons who may access an LCA and what the associated training requirements are. At SLAC, "System Laser Safety Officer" is the term used for the laser system supervisor with line management responsibility for the associated laser operations. There are two types of laser workers: i) "Qualified Laser Operators" who operate lasers and perform alignment tasks, and ii) "LCA Workers" who are usually support personnel who may need unescorted access to an LCA. All laser workers are required to receive annual On-the-Job Training (OJT), which must have an associated syllabus and must be documented.

***Lab-Specific SOP* Document**

The length of a *Lab-specific SOP* varies depending on the complexity of the laser system(s) and associated operations. The document outline does not vary much however, and a typical one is given in Figure 3. The outline notes which sections are required reading for different types of laser workers. The document utilizes figures and tables to efficiently summarize and convey information for the lab configuration, laser hazard parameters, operation modes, LSS components and functionality, and laser eyewear requirements.

Laser Personnel	Required Section Reading
LCA Workers and QLOs	1: *Introduction* 2: *Facility layout and description* 3: *Hazards Overview* 4: *Engineering Controls Overview* 5.1-5.3: *Lab-specific rules + entry/egress procedures (SOPs)* 6: *PPE overview*
QLOs	5.4: *Setting LSS operation modes (SOPs)*
QLOs, if required (depends on tasks + SLSO assignment)	5.5: *Laser operation procedures* (SOPs) 7.1: *Laser hazards* 7.2: *Non-beam hazards* 8: *Laser Engineering Controls (Detailed description)* 9: *Site-specific training details*

Figure 3: Table of Contents for the *Lab-specific* SOP

Section 1 gives a short introduction and overview of the scope of laser operations, references the *General SOP*, and contains the document outline in Figure 3 above.

Section 2 on facility layout includes a lab schematic (example shown in Figure 4) and basic information such as the lab location and whether the entryway is locked and interlocked. SLAC's Class 3B and Class 4 LCAs are required to have an entryway that is both locked and interlocked, unless the LSO approves alternate controls.

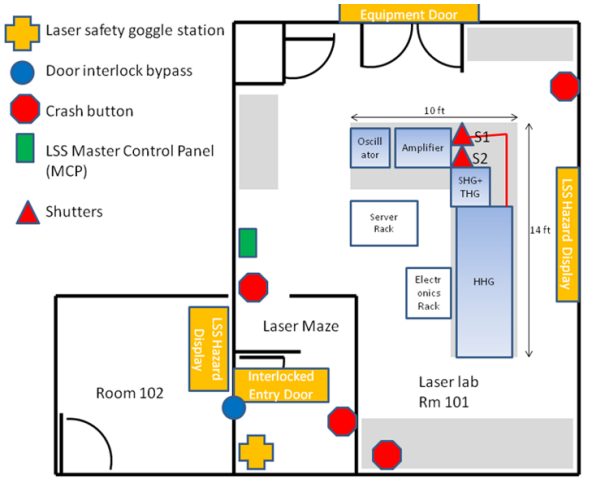

Figure 4: LCA Schematic example. The LCA is all of Room 101. Entry from Room 102 requires a valid RFID badge. The NHZ is all of Room 101 except for the entryway Laser Maze where laser eyewear is stored.

Section 3 summarizes laser hazards and non-beam hazards. It includes a table of laser hazard parameters (example shown in Table 1) and the associated laser eyewear OD requirements. Discussion of the non-beam hazards is very short, with reference given to more detailed lab-specific information in Section 7.2 and to the *General SOP* document.

Table 1: Laser Hazard Parameters (example)

Laser system	λ (nm)	Average power	Pulse width (FWHM)	Pulse energy	Repetition rate	Min OD required
Oscillator Pump	532	5 W	CW	--	CW	3.7
Amplifier Pump	527	45 W	250 ns	45 mJ	1 kHz	5.8
Oscillator	800	400 mW	25 fs	5 nJ	80 MHz	2.8
Amplifier, before compressor	800	12 W	100 ps	12 mJ	1 kHz	5.0
Amplifier, after compressor	800	7.5 W	25 fs	7.5 mJ	1 kHz	5.9
SHG, compressed	400	500 mW	25 fs	3.0 mJ	1 kHz	5.5
THG, compressed	266	100 mW	25 fs	1.0 mJ	1 kHz	5.5

Section 4 provides an overview of the lab's engineering controls. It primarily consists of a summary table (example shown in Table 2) describing the operation modes with associated permissives for safety shutters and power supplies, electronic sign display information and laser eyewear requirements.

Table 2: LCA Operation Modes (example)

Operation Mode	Shutter S1	Shutter S2	Laser Power Supply Remote Interlock	Sign Display	Eyewear
Laser Off	Closed, Disabled	Closed, Disabled	Disabled	LASER OFF ... NO LASER HAZARD	None
Class 1	Closed, Disabled	Closed, Disabled	Enabled	LASER ENCLOSED ... NO GOGGLES REQUIRED	None
Class 4 IR	Enabled	Closed, Disabled	Enabled	LASER ON ... IR GOGGLES REQUIRED	IR
Class 4 IR-UV	Enabled	Enabled	Enabled	LASER ON ... IR-UV GOGGLES REQUIRED	IR+UV
Class 4 Maintenance	Enabled	Enabled	Enabled	LASER ON – MAINTENANCE ... IR-UV-VIS GOGGLES REQUIRED	IR+UV+VIS

Section 5 covers administrative procedures. All lab laser workers must be familiar sections 5.1-5.3 on lab-specific rules and the entry and egress procedures, including for emergency entry and egress. The entry procedure includes observing what the current lab operation mode is and the associated laser eyewear requirement. Section 5.4 and associated sub-sections describe how to set or change the LCA operation mode, which include verifying correct configuration and electronic sign display information. Section 5.5 and associated sub-sections describe specific operation procedures, but only those that go beyond the "core practices" summarized in Figure 2. Examples of specific operation procedures include:

- using non-linear optics that can generate different wavelengths (for example OPAs, OPOs, OPCPAs, harmonics crystals),
- working with high power or high pulse energy laser beams, and
- maintenance or service activities that could expose additional wavelength hazards or electrical hazards.

Section 6 covers PPE and describes laser eyewear approved for use in the lab. It includes a summary table with information on the eyewear filter reference name used (see Table 2) + associated manufacturer and filter name, OD characteristics and visible light transmission. The section will note if UV beams are in use and associated skin protection requirements apply, giving appropriate reference to the *General SOP* document.

Section 7 gives more detailed information on laser hazards and non-beam hazards. A description is given for each laser source including the manufacturer and model information for commercial lasers. SLAC-built lasers and secondary sources, such as from harmonics generation, are also described.

Section 8 gives details on the engineering controls. Safety shutter characteristics and manufacturer information are summarized. Lock and interlock functionality for room doors are given, and information is provided on interlock functionality both for the SLAC-built LSS and for commercial interlocks. An example of typical SLAC LSS functionality is given in Table 3. Information is also provided for enclosures or dedicated safety devices that are not interlocked or interfaced to the LSS, but are used to contain or enable/disable certain wavelength hazards. Such enclosures and devices have appropriate laser safety device labels and need to be secured, requiring a tool to removed.

Table 3: LSS Interlock Fault Actions (example)

Interlock Condition	Mode	Action
Entry door open without bypass, or Equipment door open	Class 1	No action
	Class 4 – Normal (IR, or IR+UV)	Close and disable all shutters
	Class 4 – Maintenance	Close and disable all shutters Disable oscillator and amplifier remote interlocks Switch to Laser Off
Entry door open during bypass period	Any mode	No action
• Laser Emergency Stop activated • Emergency Entry • LSS Master Key removed • Shutter readback shows inconsistent state	Any mode	Close and disable all shutters Disable oscillator and amplifier remote interlocks Switch to Laser Off
Amplifier Cover open	Class 4 - Maintenance	No Action
	Class 4 - Normal (IR, or IR+UV)	Close and disable all shutters Disable oscillator and amplifier remote interlocks Switch to Laser Off
	Class 1	

Finally, Section 9 summarizes lab-specific training. It notes that OJT for all the lab's laser workers will cover facility operation modes and laser eyewear requirements. The OJT also reviews specific procedures a laser worker will perform and the associated hazards and controls as applicable. Detailed information on OJT specifics is given separately in an OJT syllabus document.

Other Laser Lab Documentation

SLAC's laser labs utilize SharePoint and database websites to organize their laser safety documentation. Labs have their own SharePoint and database websites, which include links to the *General SOP* and *Lab-Specific SOP*. These websites also include summary information or document links for the following:

- lab location, laser system supervisor, operation approval expiry date;
- laser inventory;
- initial and annual certification procedures;
- JSA or CCF documents that may be in effect;
- training records for the lab's laser workers and an OJT syllabus; and an
- operation approval form.

Acknowledgements

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References

[1] SLAC ES&H Manual; this states SLAC safety policy requirements. Chapter 10 is *Laser Safety*.

Meet the Author

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