Title:	Laser Safety Configuration Control and Verifying Laser Safety Barriers
Date:	October 31, 2011
Identifier:	ORPS SC--SSO-SU-SLAC-2011-0007

Lessons Learned Statement:

Laser operators made a laser safety configuration change without defining and following an appropriate work plan. The incident resulted following the move of a laser safety shutter without promptly restoring its safety functionality. This resulted in an unexpected laser beam being present until noticed on the shirtsleeve of a laser operator who was not wearing protective eyewear. The investigation team found that better safety configuration control and On-the-Job Training (OJT) would likely have prevented the event from occurring. Training and procedures need to explicitly include safety configuration control and safe methods for zero energy verification. Engineered controls should also be developed to facilitate and ensure the integrity of the safety configuration and Class 1 laser enclosures – this includes proper location, securing and labeling of safety devices; interlocked covers and barriers where appropriate; and use of safety shutters.

Incident Summary:

A laser operator visually noticed a beam from a Ti:sapphire laser oscillator on his shirtsleeve while placing an object on an optical table in a research laser lab. No laser beam should have been present, as the laser safety system had been set to "Class 1 Mode" at the end of the previous day. In this mode access is limited to qualified personnel, and it requires that all laser beams be enclosed. In this case, laser eyewear PPE is not required, and the operator was wearing none. After viewing the unexpected beam he took immediate steps to disable the laser hazard and then contacted his supervisor. The unexpected laser beam was present because a required laser safety shutter had been moved on the previous day to accommodate the relocation of a laser optic. The shutter's safety functionality was not restored and two covers for the associated shutter enclosure were also removed when the system was put into " Class 1 Mode". The laser beam was otherwise confined by other barriers on the optical table. There were no injuries and no property damage.

Incident Description and Analysis:

Description. On the day prior to the incident, laser system modifications were being done and the lead operator determined that an optic on the table needed to be repositioned to a location that required moving a laser safety shutter. The lead operator had previously discussed the scope of the work with the laboratory supervisor for the week, but did not discuss possible relocation of the safety shutter which requires supervisor approval. The shutter was subsequently removed from the beam path and laser work continued, including alignment of the repositioned optic. This was done in a "Maintenance" operation mode and other barriers were used to contain the laser beam. In "Maintenance Mode" laser beams may be present and laser eyewear PPE is

required; electronic display signs at the entrance to the lab and inside the lab indicate “LASER ON MAINTENANCE … GOGGLES REQUIRED” (in red). At the end of the day, the operation mode was changed to "Class 1", though it is unclear who set this operation mode. In Class 1 operation the laboratory access is still restricted to laser operators using their RFID, but the electronic displays signs read “CLASS 1 … NO GOGGLES REQUIRED” (in green). However, when this was done the required laser safety shutter was still removed from the beam path (the shutter is part of the Class 1 enclosure in this mode) and two required Class 1 enclosure panels were not in place (top cover and one side shield of the shutter enclosure).

The following morning, the graduate student was tasked with locating an optic to be used in the laser system downbeam of the Ti:sapphire oscillator. He entered the lab in Class 1 mode and did not wear laser eyewear (none should be required in this mode). He found the optic needed, put it near to where it would be used and then noticed the unexpected laser beam on his shirtsleeve. He then placed a beam block to contain the beam and notified his supervisor.

Analysis. The primary causal factors were:

1. Inadequate Work Planning and Control to assess potential hazards associated with moving a safety shutter and to determine if supervisor approval was needed.
2. Inadequate configuration control for laser safety devices.
3. Priority given to laser optics work rather than to restoring functionality of a laser safety device.
4. Failure to verify laser safety enclosures to ensure that a zero energy condition exists to allow Class 1 operation mode with no laser eyewear required.

Extent of Condition

1. Laser Safety Configuration Control. This is an important aspect for all laser labs. It was surprising that the lead operator made the mistake of moving the safety shutter without promptly restoring its safety functionality. The incident highlighted the importance of safety configuration control and how this gets addressed in site-specific training, written procedures, and the engineering design and controls. Weaknesses in these areas were identified both in the particular lab implementation and in the lab’s laser safety policy.
2. Laser Safety Barriers used to disable laser hazards. Class 1 enclosures are widely used, and safety shutters are sometimes used as part of these. Removable parts of Class 1 enclosures are either interlocked or are secured and labeled. These removable barriers are often not purely engineered or administrative controls, but are a combination of both. When a Class 1 enclosure condition is satisfied, laser protective eyewear is not required for the enclosed laser wavelength hazard. An example would be an enclosure to completely contain a green pump laser beam in a Ti:sapphire laser so

that eyewear protection is not required for the green beam. Another example of a barrier used to enable or disable a laser wavelength hazard can be a beam block used in front of a harmonics crystal or an OPA. When such barriers are properly used, eyewear protection would not be required for the wavelength hazard associated with the harmonics or OPA. Thus, these barriers have a similar functional role as a Class 1 enclosure. They are engineered barriers but they also have significant procedural implementation requirements – the engineered and administrative controls associated with these barriers need to have sufficient integrity to avoid the possibility of a mistake that would lead to an injury.

Corrective Actions completed:

Actions for the affected laser lab:

1. Re-position safety shutter as close to output of laser as practical.
2. Redesign shutter enclosure box to enclose only shutter and minimal optics.
3. Attach label to the shutter stating that it is a safety device requiring supervisor approval for modification. Place label directly across the mounting screw for the shutter.
4. Update On-the-job training syllabus to include identification of laser safety components and restrictions on their reconfiguration.
5. Update On-the-job training syllabus to include emphasis on importance of verification and safe ways to perform it.
6. Update On-the-job training syllabus to include demonstration of changing operation modes.
7. Rewrite Standard Operating Procedure (SOP) document to make information more accessible and to include explicit verification steps to laser safety configuration changes.
8. Post new procedures for going to Class 1 mode at point of use, which includes a specific zero energy verification step.

Actions for laser safety policy:

1. The Laser Safety Officer, with input from the Laser Safety Committee, reviewed and evaluated policy on laser safety configuration control. Configuration control requirements include:
    - OJT must identify key safety components and review configuration control requirements (OJT syllabus template was updated).
    - SOP must include procedures for configuration changes, and for moving safety shutters or other key safety components (SOP template was updated).
    - safety shutters must be placed directly at the source laser output (or can be placed in the laser cavity) or as close as practical. Safety shutter enclosures must be as small as practical – preferably to include just the shutter or the shutter and one turning mirror.
    - Laser safety device labels should be placed over the securing bolts for laser safety shutters and indicate laser supervisor approval required to move. Laser supervisors can also consider use of a special tool, an administrative lock or an interlock to improve safety

configuration control.
    - a laser safety configuration control form template will be developed for laser supervisors to use. Supervisors can then evaluate when and if to use this.
2. The Laser Safety Officer reviewed, with input from the Laser Safety Committee, requirements for Class 1 operation mode. Class 1 requirements include:
    - New guidance was given for when a Class 1 enclosure cover should be interlocked. For example, this is required when used in uncontrolled areas for covers that may be removed to enable Class 4 work, though in some cases approval may be given to use an administrative configuration control lock. Also, covers that are frequently removed or may be removed for an extended period, and may expose a different wavelength hazard when removed should be interlocked.
    - The engineered Laser Safety System should be configured so it is easy to add a new Class 1 cover interlock.
    - Labs that have a Class 1 operation mode should not permit unattended operation in this mode if they have removable Class 1 enclosures (that would enable/require Class 4 operation when removed) that are not interlocked or secured with administrative locks. Requirements or restrictions on unattended Class 1 operation must be described in the SOP and in OJT.
    - Class 1 conditions must be verified prior to setting Class 1 operation mode and when entering or exiting the lab in this mode.
    - Supervisors should consider implementing safety shutters for beam blocks that may be used to disable certain wavelength hazards (ex. for harmonics or OPA operation).

Priority Descriptor:	Yellow/Caution
Hazard(s):	Laser
ISM Core Function(s):	Hazard Assessment, Develop Hazard Controls, Perform Work within Controls.
Originator:	SLAC
Contact:	Michael Woods, SLAC; email: mwoods@slac.stanford.edu
Keywords:	laser
References:	ANSI Z136.1 “Safe Use of Lasers”