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COMPLIANCE OF SLAC'S LASER SAFETY PROGRAM WITH THE SLAC CONTROL OF HAZARDOUS ENERGY (COHE) PROGRAM*

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Abstract

SLAC's COHE program requires compliance with OSHA Regulation 29CFR1910.147, "The control of hazardous energy (lockout/tagout)." This regulation specifies lockout/tagout requirements during service and maintenance of equipment in which the unexpected energization or start up of the equipment, or release of stored energy, could cause injury to workers. Class 3B and Class 4 laser radiation must be considered as hazardous energy (as well as electrical energy in associated equipment, and other non-beam energy hazards) in laser facilities, and therefore requires careful COHE consideration. This paper describes how COHE is achieved at SLAC to protect workers against unexpected Class 3B or Class 4 laser radiation, independent of whether the mode of operation is normal, service, or maintenance.

1. Introduction

The operation of equipment, including laser systems, is considered to fall into one of three categories: normal operation, maintenance and service. In industry, normal operation generally means "production" mode where the configuration of equipment is stable. Maintenance mode means routine work is performed to maintain performance specifications for equipment. Service mode means that infrequent repair work is being carried out. The OSHA COHE (LOTO) [1] regulation states some examples of maintenance and service work to be "constructing, installing, setting up, adjusting, inspecting, and modifying machines or equipment." In an R&D laser lab, however, these examples are often considered as part of normal R&D operations as beam paths are modified and aligned and damaged optics are replaced. Unexpected energization of hazardous laser beams is therefore an important consideration during normal operations as well as maintenance and service. As noted in Appendix 1, two of the seven laser accidents in Department of Energy (DOE) facilities during the period 2001-2005 resulted in part from unexpected laser beams during normal operations.

There are important aspects of laser work in an R&D environment that have significant impact on achieving COHE for laser radiation and determining whether lockout/tagout (LOTO) is a good means to achieve COHE. Key aspects include:

- normal operations in a laser lab include tasks that are often considered service and maintenance for other types of energy hazards;

- laser personnel often work with open, hazardous beams while wearing appropriate protective eyewear;

- hazard zones, when there is an open beam, can be large and often comprise an entire room or accelerator area;

- zero energy verification for laser radiation by non-laser personnel may not be practical; and

- some laser systems have long warm-up times, while others need to keep lasers operating in one LCA that is isolated by laser safety shutters from delivering beam to a second LCA; it may not be practical to power off all laser systems in a laser facility to achieve COHE.

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OSHA LOTO requirements have generally not been considered necessary by the laser user community to provide protection to workers against unexpected laser radiation. Typical reasons given include:

- The OSHA LOTO regulations only apply to electrical hazards, not to laser hazards.
- The laser system is in normal operation mode, and so the OSHA LOTO regulations do not apply.
- The laser activation warning system prevents unexpected hazardous laser radiation, and so the OSHA LOTO regulations do not apply.
- The engineered laser safety system is equivalent to an administrative lockout and can be used instead of the OSHA LOTO controls.
- The engineered laser safety system provides an effective alternative energy control system and can be used instead of the OSHA LOTO controls.
- The laser hazard can be disabled by removing a Master Key, so LOTO is not required.

The reasons given for why OSHA LOTO requirements do not apply for laser systems are often incorrect. This can result in insufficient consideration for unexpected hazardous laser radiation, and potentially contribute to a laser injury incident.

If an engineered laser safety system (LSS) is to be used instead of LOTO, it must provide effective protection to workers performing service and maintenance and must satisfy certain failsafe criteria. Laser injuries are rare. In scientific environments the most common scenario is from not wearing appropriate protective eyewear, often during alignment procedures. Rockwell Laser Industries maintains a database of laser accidents [2]. The database has entries for 417 laser accidents between 1964 and 2001. Of these, there were 21 accidents resulting from Class 3B or Class 4 lasers in scientific environments in the U.S. between 1990 and 2001. Eye injuries were reported in 16 of these accidents – 14 occurred when no protective eyewear was worn and the other two when improper eyewear was worn. One accident resulted in an electric shock, one caused a fire and equipment damage, and the other three did not provide enough detail to determine what happened. None of these 21 cases reported failures in the LSS.

Seven DOE laser incidents occurred between 2001-2005 [3], and 6 of these resulted in eye injuries. None of these 6 incidents involved failures in the LSS. In all 6 instances protective eyewear was not worn. Alignment was being done in four of the instances, while the other two involved exposures to unexpected laser beams. As discussed in Appendix A, insufficient COHE consideration was applied in these two incidents, which partially contributed to the accidents.

2. The OSHA COHE (LOTO) Regulation and SLAC's COHE Policy

2.1 OSHA COHE (LOTO) regulation

The OSHA COHE regulation establishes control measures for COHE during maintenance and service work. The focus of the regulation, however, is solely on describing when and how to apply LOTO. Very few exemptions to LOTO are allowed. These exemptions include:

i. construction

ii. normal production operations, unless a safety device is removed or bypassed or an employee is required to place any part of their body into a danger zone

iii. work on cord & plug connected electric equipment; plug must be under exclusive control of authorized employee performing the work

iv. "hot tap operations" involving transmission and distribution systems (ex. gas, petroleum, water) provided that the employer demonstrates all of the following:

• continuity of service is essential

• shutdown of the system is impractical, and

• documented procedures are followed and special equipment is used which will provide proven effective protection for employees

v. ionizing radiation. DOE Rule 10CFR851 [4] provides an additional exemption for ionizing radiation protection at DOE labs because sufficient protection is afforded by the radiation protection programs, which include a sophisticated PPS (personnel protection system).

2.2 SLAC COHE policy

SLAC's current COHE policy [5] closely follows the OSHA COHE regulation, and again focuses almost solely on describing when and how to apply LOTO. Key aspects of LOTO policy at SLAC include:

i. Each individual worker needs to apply their own lock.

ii. In general, a written Equipment Lockout Procedure (ELP) is needed and must be followed. (Some exceptions to this are allowed as described in References [1] and [5].)

iii. All equipment requiring service and maintenance must have an equipment custodian; this person is responsible for assuring that a compliant ELP exists for such equipment before it is serviced.

iv. Lockout is applied to an energy isolation device after equipment is de-energized

v. Zero energy verification is required after de-energizing the equipment.

vi. Whenever new machines or equipment are installed, energy isolating devices for such machines or equipment shall be designed to accept a lockout device.

vii. Workers applying LOTO must be authorized; authorized workers can perform servicing and maintenance work and apply LOTO after receiving appropriate training and demonstrating proficiency in LOTO to their supervisor.

SLAC's COHE policy is currently being updated. Input for laser safety considerations has been submitted for this revision and is being carefully considered. The policy is being expanded to provide guidance on COHE more broadly than just a focus on when and how to apply LOTO. It includes a description of an administrative lock and tag policy, which can be used to protect workers from hazardous energy when they are not performing service or maintenance work. Another important aspect in a draft version of the new policy includes an exception to LOTO for some systems that employ an alternative energy control system to control access and protect workers. For a LOTO exception, the hazards and controls associated with such alternative control systems must be documented in an alternative energy control plan and provide a level of safety equivalent to a lockout/tagout. For laser safety systems, the plan must be reviewed and approved by the Laser Safety Officer.

SLAC's Class 3B and Class 4 laser facilities have an engineered Laser Safety System (LSS), and the associated laser hazards and controls are documented in Standard Operating Procedures (SOPs) [6]. The LSS and SOPs can constitute an effective alternative energy control system. The LSS and SOPs are reviewed by a Laser Safety Committee (LSC), with final review and approval by the Laser Safety Officer (LSO). Annual audits are performed, and renewal of operation approval by the LSO is required every year. The LSO and LSC require that the LSS and SOP enable qualified laser operators (QLOs) to safely use Class 3B and Class 4 lasers, and also provide effective protection for all workers against the unexpected energization of Class 3B and Class 4 laser radiation.

3. Laser Safety Standards for Laser Users and Manufacturers

The ANSI Z136.1 standard [7] provides little discussion or guidance on compliance with the OSHA COHE (LOTO) regulation. LOTO is mentioned only three times in the standard. First, ANSI Section 4.3.4 discusses key control and requirements for a "Master Switch" for Class 3B and Class 4 lasers, stating that "all energy sources associated with Class 3B or Class 4 lasers shall be designed to permit lockout/tagout procedures required by OSHA." This section also states that "during periods of prolonged non-use, the master switch should be left in a disabled condition (key removed or equivalent)," implying that key removal is sufficient to disable the laser hazard. Second, Appendix F Section F1.1.5 discusses electrical safety associated with laser systems; here the ANSI standard states "Where applicable, the user should comply with provisions of OSHA Standards for Electrical Safety-Related Work Practices (29 CFR 1910 Subpart S) and the Control of Hazardous Energy (lockout/tagout; 29 CFR 1910.147)." Lastly, ANSI Section 4.5.2.2 discusses fiber optic transmission for Class 3B or Class 4 radiation and states "It is recommended that appropriate procedures be instituted to prevent inadvertent personnel exposure from an unterminated or severed fiber, such as lockout/tagout requirements at the laser source." In this last case, it is clear the ANSI standard is recommending consideration of LOTO to protect against the laser hazard. Here it is felt that the service repair or maintenance work may involve the worker directly inspecting the laser fiber, so it is imperative that the laser hazard be disabled to avoid the possibility of a direct intrabeam exposure.

The ANSI laser standard is a consensus standard that provides guidelines for the safe use of lasers to be adopted voluntarily by users. OSHA does not require compliance with this standard, though OSHA auditors can issue citations for violations of the standard. The DOE adopts a more rigorous policy with Rule 10CFR851 [4] requiring DOE contractors and subcontractors to comply with the ANSI laser standard. Some guidance on COHE considerations for lasers is also afforded by examining requirements for laser manufacturers by the U.S. Food & Drug Administration (FDA), which stipulate that laser manufacturers must certify that their laser products satisfy requirements in CDRH (Center for Devices and Radiological Health) regulation 21CFR1040.10 [8]. This regulation does not explicitly discuss lockout/tagout but does state a requirement for a Master Key, "Each laser system classified as a Class 3B or 4 laser product shall incorporate a key-actuated master control. The key shall be removable and the laser shall not be operable when the key is removed."

In addition to key (or master switch) control for disabling laser hazards, the ANSI standard and the CDRH regulation also include requirements for laser activation warning systems for Class 3B and Class 4 lasers to protect laser users against unexpected startup or energization of hazardous laser energy. The CDRH regulation requires that "each laser system classified as a Class 3B or Class 4 laser product shall incorporate an emission indicator which provides a visible or audible signal during emission of accessible laser radiation in excess of the accessible emission limits of Class 1, and sufficiently prior to emission of such radiation to allow appropriate action to avoid exposure to the laser radiation." ANSI Z136.1 requires an audible or visual activation alarm, but no longer requires an emission delay; the 1993 ANSI Z136.1 required an emission delay, but this requirement is no longer present in the 2000 and 2007 versions. ANSI Z136.1 states in 4.3.9.4 that "an activation warning system should be used with Class 3B, and shall be used with Class 4 lasers or laser systems during activation or startup."

4. Current interpretations of COHE compliance for hazardous laser radiation

The COHE interpretation of the ANSI laser standard for laser users and the CDRH regulation for laser manufacturers has generally been (at SLAC, at other DOE labs and elsewhere) that

i. the activation warning system, together with key control, protects against the unexpected startup or energization of hazardous laser energy,

ii. removing a Master Key or disabling a Master switch is sufficient to disable the laser hazard and permit service or maintenance work without the need for laser protective eyewear or LOTO, and

iii. LOTO is only needed when servicing electrical equipment (and in many cases LOTO for electrical service or maintenance work on laser systems can be satisfied by cord & plug control).

5. SLAC Laser Safety Policy Relevant to COHE

5.1 Policy prior to 2008

Until recently, SLAC laser safety policy has interpreted the OSHA COHE regulation to refer only to lockout/tagout (LOTO) requirements when servicing or maintaining electrical equipment (ex. power supplies, modulators, flashlamps) associated with laser systems. The engineered Laser Safety System (LSS) with a restricted-access Laser Controlled Area (LCA), Master Key, activation warning system and interlocked laser safety stoppers has been deemed sufficient to ensure COHE protection against unexpected laser radiation exposure for workers from Class 3B and Class 4 lasers.

Key aspects of SLAC Laser Safety policy with relevance to COHE has included:

a) Restricted access. Access to the LCA must be through a locked door, restricted by key or coded access to qualified laser operators.

b) LSS response to an unauthorized entry into an LCA. Unauthorized entries result in the LSS inserting shutters or disabling laser power supplies or their interlocks to prevent exposure to hazardous laser radiation.

c) Master Key. A Master Key is required to enable an LCA Master Controller. Removal of the Master Key disables all Class 3B and Class 4 laser beams in the LCA. Access to the Master Key is restricted to approved Laser Operators.

d) Activation request and warning. Once the Master Key enables the laser system, an additional manual request is required for system startup or re-energizing. The manual request is accompanied by an audible alarm and an emission delay (lasting ~10 seconds).

e) Protective eyewear. Protective eyewear is required when the Master Key enables the Master Controller. Work in the lab without protective eyewear requires that the Master Key be removed from the Master Controller.

f) Standard Operating Procedures (SOP) and System Laser Safety Officer (SLSO). A written SOP document is prepared by the SLSO, and must be approved by the LSO. The SOP describes the laser facility hazards, engineering controls, administrative controls, protective eyewear requirements and training requirements. The

SLSO is responsible for day-to-day safety in the laser facility and for providing facility-specific and on-the-job training to laser personnel.

5.2 Recent Policy Updates

The DOE has recently been emphasizing the importance of good LOTO practice at its national labs, which has prompted SLAC to update its COHE and LOTO policies. This also prompted a careful examination of SLAC's laser safety program regarding its compliance with the OSHA LOTO regulations, which has resulted in a number of updates to the lab's laser safety policy that are now being implemented. These updates include clarifying and making explicit some key requirements that are relevant for COHE to protect workers against unexpected hazardous laser radiation. New laser installations are required to adhere to these, while existing facilities require an LSO evaluation to determine what actions are needed. A list of these policy updates follows.

a) Laser safety shutters. These are primary safety devices in the LSS. However, SLAC did not have explicit requirements for them. The new requirements are:

• Shutters have independent readback sensors for the IN and OUT positions.

• Shutters must close when control signals or power are deactivated or removed.

• When there is an inconsistency between the requested state and the IN and OUT sensors, the LSS must give an alarm warning and if possible inhibit the laser upstream of the shutter.

• Shutters' manufacturing information must be described in the SOP, including an evaluation of their ability to withstand the maximum laser irradiance.

• Shutters must be labelled Laser Safety Devices, which can only be removed per instructions in a documented procedure approved by the SLSO.

b) Laser transport shutters. When Class 3B or Class 4 laser beams can be transported between two LCAs or if a Class 1 laser system containing such beams terminates in a transport shutter in an area that is not an LCA, then either i) 2 redundant transport shutters must be installed, or ii) if only 1 shutter is used, LOTO capability is needed for achieving COHE by being able to lockout the shutter or apply a blankoff flange on the transport line. Note that COHE is not needed in a laser facility if the beam path is fully enclosed, satisfying the requirements for a Class 1 laser, and is terminated in a permanent beam dump. If the laser beam is used in a production accelerator facility, the preferred solution is to implement Class 1 enclosures with permanent, fixed beam dumps.

c) Laser Safety System Interlocks. LSS interlocks for access doors, protective covers, service access panels and enclosures must be normally open. 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.

d) Key control requirements and practice. Key control for the LCA Master Key and other keys for Class 3B and Class 4 lasers is an integral part of the engineered LSS and SOPs, and is recommended to be used as an alternative energy control to LOTO in many instances. These key control procedures must be followed with the same discipline as LOTO procedures must be followed.

e) LSS failures. All failures related to the LSS, including laser safety shutters and interlocks, must be reported to the SLSO and to the LSO. The LSO must make a determination if the failure is severe enough to be a reportable occurrence.

f) Zero energy verification. The SOP document and QLO training must describe procedures to be used for zero energy verification, which must be done before protective eyewear is removed.

g) LCA search prior to enabling laser hazard. Prior to enabling the laser hazard, the responsible QLO will search the LCA to require all personnel present to wear appropriate protective eyewear and give warning of the laser hazard being enabled.

h) Service and maintenance.

• The SOP document must describe what defines service and maintenance mode. 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 and maintenance work is in progress; it must indicate any change in protective eyewear requirements.

• When an interlocked cover or service access panel is removed, the LSS must be evaluated for any changes in its normal functions (for example, the LSS normally prevents laser hazards by inserting stoppers and providing 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. This must be documented in the SOP, or in the SSSP (site specific safety plan) and JSA (job safety analysis) forms required for subcontractor work.

i) Permitted or open access. When an LCA is left in permitted or open access, the LCA Master Key and all other keys that may enable Class 3B or Class 4 lasers in the LCA must be removed. The keys must be placed in a key box with access restricted to the SLSO or laser facility program manager (or a QLO they may designate).

j) Connecting/disconnecting fiber optic cables for Class 3B or Class 4 laser radiation. Connectors must be secured, requiring a tool for removal, and must have a label stating "DANGER -- Hazardous Laser Radiation when Disconnected." Protective eyewear must be worn if connecting/disconnecting is done without disabling the laser hazard. It is strongly recommended, however, to disable the laser hazard first. If the fiber terminations are to be directly inspected, then the laser hazard must be disabled – protective eyewear can never be relied on to permit direct intrabeam viewing. Disabling the laser hazard may be done by a QLO removing the laser's enabling key or Master Key; if this cannot be done, then LOTO must be used unless cord & plug control can be used. The SOP must describe the procedure used or the LSO must give documented prior approval to this work if it is not described in the SOP.

k) Training. SLSOs and laser facility program managers must take a COHE awareness training course. If laser personnel need to apply LOTO, then appropriate LOTO training must additionally be taken. The LSO is required to take the COHE awareness training and be knowledgeable of SLAC's COHE policies. All laser personnel must be trained to exercise the same discipline for applying COHE practices (ex. key control, zero energy verification, LCA searches) as would be expected for LOTO practices.

l) Equipment custodians. The SOP document must describe who is responsible for equipment described in the SOP.

m) Establish authority for COHE in laser facilities. The LSO has primary authority for laser safety policy, but must ensure that these policies comply with the lab's COHE policies. The LSO will consult with the COHE program manager and lab safety management as needed. When the LSO and COHE program manager disagree on applying COHE policy for laser facilities, the LSO must respect the requirements determined by the COHE program manager. The LSO may, however, appeal to the lab's Chief Safety Officer, who will then make a policy determination for the requirements to follow.

6. COHE and LOTO evaluation for different laser operation scenarios

In this section, I summarize COHE evaluations for 8 laser operation scenarios that may occur at SLAC, and consider whether LOTO should be required. The 8 scenarios considered are:

a) Protective eyewear is worn during normal operations, maintenance or service.

b) Protective eyewear is removed.

c) A laser safety protective cover is removed or bypassed.

d) Laser service work is performed by subcontractors.

e) Non-laser personnel perform work in a restricted access LCA.

f) Non-laser personnel perform work in a self-contained laser facility during periods of open or permitted access.

g) Non-laser personnel perform work in a laser facility during periods of open or permitted access, when such facility is connected by a laser transport tube to another LCA that may be in use.

h) Fibers are connected or disconnected in a fiber optic transmission system that encloses Class 3B or Class 4 laser radiation.

The engineered LSS and detailed SOPs for each LCA are reviewed and approved by the LSO, and are required to provide effective protection against unexpected laser radiation exposure to all workers from Class 3B and Class 4 lasers. The use of LOTO would generally only provide additional protection if there is a failure in the LSS. There could also be a failure in laser personnel following administrative procedures, but LOTO also entails administrative procedures with an inherent risk that they may not be correctly followed.

For scenario a), LOTO would not be used because the laser hazard is present and protective eyewear is worn. LOTO does need to be considered for the other scenarios b)-h). However, LOTO presents significant difficulties for use in laser facilities. These difficulties include:

• In the LSS failure scenarios, generally the entire LCA becomes a hazard zone and everyone entering the LCA would need to apply LOTO. Applying LOTO on a routine basis by many people for extended periods of time can lead to bad LOTO practice.

• Non-laser personnel may include people like janitors for whom LOTO is not appropriate.

• LOTO requires zero energy verification, which can be difficult and not practical for non-laser personnel.

• What may be considered service work in other activities is often considered normal operations in R&D laser labs as noted in Section 1. The distinction between service work and normal operations gets blurred, and the work done by laser service subcontractors often has similar or identical hazards and hazard controls as occur in normal operations and are addressed by the LSS and SOPs. It may not be practical for laser personnel to apply LOTO frequently in the course of a routine work day.

For the 8 scenarios considered, LOTO is generally an option that would only be utilized for scenario h), and then only if key control or cord & plug control cannot be used. For scenarios b)-g) usually there are compelling reasons to invoke the exception listed in Section 2.2 of this memo that the LSS and SOPs provide an effective alternative energy control system. In scenarios a)-d), the affected personnel are well-trained laser personnel working in a restricted-access laser facility. In scenario e), non-laser personnel must be accompanied by a QLO. In scenarios f) and g), the lasers in the laser facility are disabled by removing the LCA Master Key and all power supply keys for Class 3B and Class 4 lasers. The key control for these two scenarios would likely be done as part of an administrative lock & tag to secure these keys.

7. Recommended changes to the OSHA COHE (LOTO) Regulation

This regulation has been developed without adequate consideration for how Class 3B and Class 4 lasers are used, in particular in an R&D environment. It has been developed with a focus on electrical safety in an industrial environment, yet has much broader applicability than this. In my opinion, the following items need to be evaluated for updating the policy:

i. COHE definition. I recommend it be defined to be "Control measures used to protect workers from the unexpected energization or startup of hazardous energy." This would apply to all modes of operation: normal, maintenance and service. COHE needs to be distinct from LOTO. LOTO is one means to achieve COHE to protect workers during service and maintenance.

ii. 3 key COHE practices. These are LOTO, administrative lock & tag, and an alternative energy control system. LOTO is the primary COHE practice to protect workers performing service and maintenance. Administrative lock & tag can be used to provide COHE protection to workers when they are not performing service and maintenance. Lastly, an alternative energy control system is an alternative to LOTO or administrative lock & tag that can be used to provide COHE protection to workers when it can do so with sufficient effectiveness. This alternative system must be documented in an alternative energy control plan. (An engineered LSS and associated SOPs would be one example of an alternative energy control system.)

iii. Potential problems or concerns with applying LOTO should be noted, which may lead to implementing an alternative energy control system as a better control measure. Some of these issues include:

    • When LOTO is applied there are strict guidelines governing how to apply it. One needs to avoid situations that encourage bad LOTO practice.

    • If LOTO needs to be applied frequently by many workers on a given system for extended periods, there should be concern that bad LOTO practice will result and there should be adequate consideration for an alternative energy control system.

    • Zero-energy verification may not be practical to be performed by affected workers, in particular as regards hazardous laser energy.

Summary

The OSHA COHE (LOTO) regulation specifies requirements for when and how to apply lockout/tagout to protect workers against the unexpected startup of hazardous energy during service and maintenance. This regulation effectively makes COHE and LOTO synonymous, and the focus is completely on when and how to perform LOTO. It is deficient in that inadequate consideration is given to alternative control measures and to problems and deficiencies in applying LOTO. The regulation has also been developed without adequate consideration for how Class 3B and Class 4 lasers are used.

The ANSI laser safety standard and many existing laser safety programs are also deficient in that they haven't properly addressed compliance with the OSHA COHE (LOTO) regulation.

Recently, the DOE has emphasized the importance of good COHE and LOTO practice at its labs, with a need to comply with the OSHA LOTO regulation. This has resulted in reviews and updates of COHE and LOTO practices at SLAC, which has also led to a review and update of SLAC's laser safety policy for this. Laser safety issues are an important consideration for the updates being implemented to SLAC's COHE and LOTO policies.

SLAC's laser safety policy is being updated with many additional COHE requirements, which include explicit specifications for engineering and administrative controls. These updates are needed to adequately address compliance with the OSHA COHE (LOTO) regulation and to enable the engineered laser safety system and SOPs to satisfy the requirements for an alternative energy control system. In general, COHE is best achieved in most circumstances by use of the LSS and SOPs without using LOTO, though LOTO is an option that may be used.

Finally, there is a need to update the OSHA COHE (LOTO) regulation to take proper account of laser safety issues. The ANSI Z136.1 regulation should also better address compliance of laser safety policies with this OSHA regulation in its next update.

References

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[10] ORPS Report GO--NREL-NREL-2005-0001.

APPENDIX 1: COHE Considerations for Recent Laser accidents at DOE Labs

Seven laser accidents occurred at DOE labs between 2001-2005 [3]. In two of the accidents, students thought that the laser was off or that the laser beam had been attenuated to a safe level and removed their protective eyewear. In one case at LANL, the student looked into the laser beam path after a beam dump had been removed by their supervisor [9]. In the other case at NREL, the student reduced the laser beam power to a supposedly safe level with ND filters and removed his protective eyewear to assist viewing an oscilloscope; the student then removed a sample in the beam path with metal tweezers and was struck in the eye with a reflected laser beam [10].

In the ORPS reports for these 2 laser accidents [9,10], the operations mode was defined to be "Normal operations" for each case. The safety analysis focused on unsafe work practices, failures to follow SOPs and failure to wear protective eyewear. No consideration was given for what COHE analysis and control measures should have been taken if one wanted to remove protective eyewear. I agree with the ORPS report that the mode of operations was normal, rather than maintenance or service. But I think it is a serious oversight to not evaluate COHE during normal operations for laser labs, in large part because laser lab work and the control of hazardous Class 3B or Class 4 laser radiation is often not very different whether working in normal, maintenance or service operation modes. It is a routine occurrence in laser labs to spend part of the work day in the lab without protective eyewear; evaluation and application of COHE needs to be performed for this.

For the LANL case cited above, a policy requiring removal of a Master Key to disable the laser hazard followed by zero energy verification would have been sufficient to avoid the accident. Alternatively, if the laser and its beam path needed to be enabled the experiment could have been performed while wearing protective eyewear with a camera set up for remote viewing. For the NREL accident, the student reduced the beam power with ND filters and then removed his protective eyewear. The student forgot to put the eyewear back on before removing a sample in the beam with a pair of metal tweezers. Again, evaluation and application of COHE should have been undertaken to prevent access to hazardous laser beams when protective eyewear is not worn. One possible COHE action that would have prevented the NREL accident would have been to enclose and apply LOTO to the section of the laser table with the ND filters and areas with hazardous laser beams above the MPE level. For all scenarios, it should also be required that an activation warning system be operable (as described in the SOP) to give adequate advance warning to the startup of a new hazardous laser beam. For both the LANL and NREL accidents, the activation warning systems were deficient for the operation tasks being performed.

Meet the Author

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