Laser Safety Plan

INTRODUCTION

Since the human body is vulnerable to the output of certain lasers, under certain circumstances, exposure can result in damage to the eye and skin. Research relating to injury thresholds of the eye and skin has been carried out in order to understand the biological hazards of laser radiation. According to both the Laser Institute of America, publisher of the ANSI Z.136 Standard series on laser safety and the U.S. Department of Labor's OSHA division on Laser Hazards, "It is now widely accepted that the human eye is almost always more vulnerable to injury than human skin."

Because of this vulnerability to laser light, a variety of laser safety standards including Federal and state regulations, and non-regulatory standards have evolved. The most widely accepted and used standard is the American National Standards Institute's Z136 series of laser safety standards. These standards are the foundation of laser safety programs in industry, medicine, research, and government. The ANSI Z136 series of laser safety standards are referenced by the Occupational Safety and Health Administration (OSHA) and many U.S. states including Maryland as the basis of evaluating laser-related occupational safety issues.

ANSI Z136.1 Safe Use of Lasers, adopted as the foundation for this manual and the University UMCP Policy on Occupational Exposure to Laser Light, provides information on how to classify lasers for safety, laser safety calculations and measurements, laser hazard control measures, and recommendations for Laser Safety Officers in all types of laser facilities.

All laser devices distributed in the U.S. are subject to meeting the Federal Laser Product Performance Standard (FLPPS) and the requirements of the FDA's Center for Devices and Radiological Health Office (CDRH) of Compliance. This performance standard specifies the safety features and labeling that all laser products must have in order to provide adequate safety to users.

This combination of standards and laws provide University researchers and laser safety personnel with the information needed to properly develop and practice a comprehensive laser safety program.

Scope

The use of lasers has become widespread in research and industry and continues to increase with changes and development in technology and the fields of science. This document provides the requirements needed to implement University Policy **VI-16.00(A), UMCP POLICY ON OCCUPATIONAL EXPOSURE TO LASER LIGHT**. All personnel using lasers at the University of Maryland are required to comply with the requirements of this Policy and this Manual.

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University of Maryland Personnel Responsibilities and Duties

Principal Laser User (PLU)

Class 3R, 3B and 4 lasers and laser systems at the University of Maryland must be assigned to a responsible individual designated as the Principal Laser User. The PLU's responsibilities include:

(a) Planning and implementation of all safety measures required for safe laser use in the laboratory;

(b) Completion in a timely manner of a Laser Registration Form for each Class 3B or 4 lasers.

(e) A written Standard Operating Procedure (SOP) in a location readily available to laser operators for all Class 3B and 4 lasers and ensures compliance with the SOP.

(f) Supervision in the safe use of lasers in the laboratory;

(g) Ensuring all lasers under the PLU's control are properly classified and labeled.

(h) Establish and maintain a list of personnel approved to operate Class 3B or 4 lasers; keeping the Laser Safety Officer up to date on personnel authorized to use the laser(s);

(i) Assuring completion of the University Laser Safety Training course by all personnel in the lab; assuring attendance at refresher training once per year following the completion of the University Course for all personnel using lasers in the lab.

(j) Immediately notifying the LSO in the event of a suspected overexposure to laser light.

(k) Following the disposal directions for unwanted lasers in the Laser Safety Manual.

Laser User (LU)

Only a PLU or an LU may operate a Class 3B or 4 laser. Each LU must initially work under the supervision of a PLU. LU responsibilities include:

(a) Completing the University Laser Safety Training class before operating a Class 3R, 3B or Class 4 laser; attending refresher training once per year following the completion of the University Course.

(b) Using lasers safely.

(c) Complying with established policies, SOPs and other procedural requirements.

(d) Promptly reporting to the PLU any malfunctions, problems, accidents, or injuries, which may have an impact on safety.

(e) Not disabling, removing, or modifying any safety control systems without prior written approval from the PLU.

University of Maryland LSO Responsibilities

Department of Environmental Safety (DES) Laser Safety Officer (LSO)

The LSO responsibilities include:

(a) Administering the day-to-day operation of the Laser Safety Program.

(b) Maintaining an up to date inventory of Class 3R, 3B and 4 lasers.

(e) Performing laser hazard analyses and audits; ensuring, by follow up and additional audits as necessary, that all laser safety deficiencies are addressed and resolved.

(g) Restricting or terminating the use of lasers that present an imminent danger or excessive hazard.

(h) Ensuring the availability of proper laser safety training.

(i) Making recommendations for selection of proper personnel protective equipment.

(j) Investigating laser accidents and near misses.

(k) Updating the UMCP Policy on Occupational Exposure to Laser Light and manual on an annual basis.

(l) Reviewing, approving, and maintaining a copy on file of all laser SOPs.

(m) Maintaining laser safety training records;

(n) Providing periodic reports on the status of laser safety to the Radiation Safety Officer (RSO) and Executive Management, and promptly informing the RSO of any imminently hazardous laser issues.

Laser Classification

All lasers and laser systems in the U.S. are categorized into one of several hazard classes. Labels affixed to the laser or laser systems identify the hazard class according to the ANZI Z136.1 Laser Standard. The manufacturer provides the classification for most lasers; for custom-built and modified lasers, the LSO will assist you in classifying your laser. The following laser classes apply to the use of lasers and laser systems. It is important to understand the different classes in order to work safely with laser light.

Class 1

• Do not emit harmful levels of radiation during normal operation.
• Typically visible radiation, Continuous Wave (CW) with power levels < 0.4 μW.
• The maximum exposure duration limit for viewing is assumed to be no more than 30,000 seconds; in the IR region > 0.7 μm the duration limit is 100 seconds.
• A Class 1 laser system can include higher class lasers completely enclosed and interlocked to prevent beam access, allowing a Class 1 laser system designation; any time the higher class laser is accessible (e.g. during alignment or servicing), the higher laser class controls must be observed.
• A Class 1 laser or laser system can be used without restriction in the manner intended by the manufacturer and without special operator training, qualification or surveillance.
Previously classified 2A lasers by the Federal Laser Product Performance Standard may be treated at Class 1 lasers or laser systems.

Class 1M

• Do not emit harmful levels of radiation during normal operation ***unless viewed with optics***.
• Two conditions exist that present a hazard when viewed through optics:
    1. If a beam is diverging, and a lens is placed within 100 mm of the aperture to focus the beam into the eye;
    2. If a beam has a large diameter, and a lens is used to increase the amount of laser light entering the eye.
• LEDs and fiber optic communication systems typically fall into this classification.
• A Class 1M laser or laser system can be used without restriction in the manner intended by the manufacturer and without special operator training, qualification or surveillance.

Class 2

• Emits accessible laser light in the visible wavelength region, (0.4 to 0.7 μm) and is capable of creating eye damage through chronic exposure.
• Radiant power level emitted is above class 1 (0.4 μW) but less than 1 mW.
• The blink reflex (aversion response to bright light) provides adequate protection.

• A Class 2 laser can be used without restriction in the manner intended by the manufacturer and without special operator training or qualification.

Class 2M

• Is restricted to laser light in the visible wavelength region, (0.4 to 0.7 μm), and the blink reflex (aversion response to bright light) provides adequate protection for unaided viewing (no optics).
• A class 2M laser can be dangerous when viewed through optics.
• A class 2M laser power can exceed a class 2 (1mW) level, however the beam is either highly divergent or the beam diameter is large so that only a small proportion of the light enters the eye.
• A Class 2M laser can be used without restriction ***in the manner intended by the manufacturer*** and without special operator training or qualification.

Class 3 Lasers (3R and 3B)

• Class 3 lasers are hazardous under direct (intrabeam) or specularly (mirror-like) reflection viewing but are not normally considered to be a diffuse viewing hazard or fire hazard.
• The Class 3 category is broken down into 2 distinct classifications: 3R and 3B.

Class 3R

• Invisible (< 0.4 μm and > 0.7 μm), and visible (0.4-0.7 μm) radiation emission;
• This laser classification presents a hazard if the eye is focused and stable. A class 3R laser is not a diffuse viewing hazard or a fire hazard.
• Class 3R lasers are restricted to 1-5 mW in power and can be considered safe for momentary viewing except in the case of optics.

Class 3B

• Invisible emission: Restricted to 125mJ per pulse and 5-500 mW CW in < 0.25 seconds
• Visible emission: Restricted to 30mJ per pulse and 5-500 mW CW in < 0.25 seconds.
• This laser classification will cause injury upon direct viewing of the beam and specular reflections, but is not normally a fire hazard, or diffuse viewing hazard unless done under conditions of intentional staring within the diffuse hazard distance.
• Specific controls must be in place to operate a class 3B laser. All personnel operating such a laser or laser system must complete training before use.
• Eyewear is required for all Class 3B unenclosed laser use.

Class 4

• These laser or laser systems contain high powered lasers > 500 mW or 125mJ per pulse in < 0.25 seconds. **This laser or laser system is a hazard to the eye and skin under any viewing conditions if viewing directly, specularly or within the diffuse reflection safety distance.**
• **This laser class can also produce laser generated air contaminants (LGAC) and potentially hazardous laser plasma radiation.** Specific controls must be in place to operate a class 4 laser. All personnel operating such a laser or laser system must complete training before use.

• Eyewear is required for all Class 4 unenclosed laser use.

Laser Acquisition, Transfer, and Disposal

Acquisition: Notify the Laser Safety Officer through the Department of Environmental Safety of any decision to purchase, fabricate, or otherwise acquire a **3R, 3B or Class 4 laser** or laser system. The LSO will review the hazards of the proposed device and assist the end user in compliance regarding the specific safety requirements that pertain to the proposed use, including but not limited to requirements for SOPs, laser control areas, training, and personnel protective equipment.

Transfer & Disposal: The PLU is required to notify the LSO of any class 3b or 4 laser or laser system relocated, or transferred to another PLU or institution, or sent offsite as surplus equipment.
Laser users have an obligation to ensure safe and responsible disposition of their unneeded, but potentially hazardous, class 3b or 4 lasers and laser components. Appropriate means of laser disposal include:

1. Donate the laser to an organization (e.g. school, industrial company, hospital) with a need for such a device. The donor should ensure that the donated laser system complies with all applicable product safety standards and is provided with adequate safety instructions for operations and maintenance. The donor should also verify that the receiving organization has a viable laser safety program. The LSO will assist the PLU in verifying viable laser safety programs prior to any transfer, shipment or relocation off-site of the University.
2. Return the laser to the manufacturer, or to a vendor specializing in re-selling used laser equipment.
3. Eliminate the possibility of activating the laser by removing all means by which it can be electrically activated. Once this has happened the laser could then be discarded.
4. Destroy the laser.

The last two methods also require proper removal and disposal of any hazardous materials found inside the laser components, such as mercury switches, oils, dyes, etc. Users should contact the LSO if they need further information or assistance with proper disposal. Terrapin Trader routinely does not accept such devices without approval from the LSO regarding the hazards of the laser and the components themselves.

Laser Hazard Control Measures

Controls for Class 1, 1M, 2 & 2M Lasers

Class 1, 1M, 2 and 2M can be used without restriction *in the manner intended by the manufacturer* and without special operator training or qualification. Any laser may become hazardous when viewed through optics, in particular Class 1M and 2M: therefore, consultation with the LSO is required prior to utilizing optics that would focus light on the eye from any of these classes or that would exceed the MPE or classification status of the manufactured laser. In this case both procedural and administrative controls are required.

Controls for Class 3R, 3B &4 Lasers

Class 3R, 3B and 4 lasers may be operated only in designated laser controlled areas approved by the LSO. All personnel authorized to enter a Class 3R, 3B and Class 4 laser controlled area shall be appropriately trained, and must follow all applicable administrative and operational controls. All personnel operating a Class 3R, 3B or 4 laser shall have completed laser safety training and be approved by the PLU to operate the laser. Controls for these classes are in accordance with appropriate safety measures based on (1) engineering controls, administrative and procedural controls, and personal protective equipment controls. In all cases where engineering controls become impractical or inadequate, administrative, procedural and personal protective equipment controls shall be utilized. Personnel are required to wear eyewear for all unenclosed laser use which involves Class 3R, 3B and 4 lasers.

In particular class 3B and class 4 controlled areas shall:

(1) Be operated only by trained and approved Laser Users (LU);
(2) Be posted with the appropriate DANGER warning sign;
(3) Have a well defined beam other than sitting or standing eyelevel;
(4) Be under supervision of PLU;
(5) Have an appropriate beam stop;
(6) Have only diffusely reflective material in or near the beam;
(7) Have the appropriate required eye wear for personnel;
(8) Control access by key removal.

Entryway Controls for Class 4 Lasers

A class 4 laser system controlled area, in addition to the 8 particular requirements for control as listed above, shall have one of the following access control measures incorporated as a standard operating procedure:

(1) Non-defeatable (non-overriding) Entryway Control: An electrical, magnetic, pressure sensitive, IR detectable device shall deactivate the laser to below MPE levels when unexpected entry is affected into the laser controlled area.

(2) Defeatable area Entryway Control: If, during normal operation, the MPE shall not be exceeded by unexpected entry to the laser controlled area, an interlock or other control may be defeatable to allow access to authorized (trained) personnel. (Note: training shall be commensurate with the level of authorized use; i.e. personnel not utilizing the laser or laser systems but requiring access to laboratory space in the laser controlled area shall be required to complete awareness training of laser hazards in their lab. Awareness training shall be available through the LSO and signed off on by both the LSO and the PLU.
(3) Procedural (Administrative) area Entryway Control: May be utilized when the MPE is not exceeded at any barrier used to maintain control of the beam path. All personnel shall be trained commensurate with their activity in the laser controlled area. A clearly visible warning system (light and/or audio) shall be energized to alert personnel entering that the laser is in operation.

Operation, Maintenance and Service Activities

The classification and control of lasers may change during any of these 3 particular activities:
• Operation as the routine use of the laser through a standard operational procedure available in the manufacturer manual or specially written by the PLU for a particular experiment use.
• Maintenance as a routine performed with some set frequency which may require such actions as cleaning and replenishing systems.
• Service as performed with less frequency than maintenance and is required to be performed by a person knowledgeable in the unique hazards associated with servicing the equipment. In this case for example, an enclosed laser classified as Class 1 may become a class 3B or 4 during service. Such action would require a higher hazard classification for some temporary time during which service is performed. During such activities as maintenance and service the NOTICE and TEMPORARY DANGER sign shall be posted on the facility to warn personnel of potentially imminent hazards of laser light.

Alignment Procedures: Alignment procedures are the responsibility of the PLU and their approved LUs. Only trained personnel shall perform alignment of the laser system. Personnel learning how to align a laser shall be under direct supervision of the PLU or an approved LU. The following actions are recommended for alignment procedures:

(1) All unnecessary personnel shall be protected from or removed from the area;
(2) Use the lowest power setting OR another low power laser;
(3) Wear protective eye wear;
(4) Use image converters for phosphor cards to locate beams;
(5) Block all beams not required for alignment purposes;
(6) Use curtain or closed doors when available to limit stray beams;
(7) Post any additional appropriate warning signs at the entrance to the laser controlled area.

Protective Equipment: In all cases involving class 3B and class 4 laser systems the preferred method of control is complete and total enclosure of the beam. When this is not feasible other protective equipment shall be utilized commensurate with the hazards and operation. Such

equipment shall consist of approved laser curtains, eye wear, filters, clothing, local exhaust and other barriers.

Personal Skin Protection: Skin protection can be afforded using engineering controls to enclose beams and reduce diffuse reflections which may cause unwanted skin affects over time due to chronic exposure. UV light and FIR radiation in particular are of concern in the lab. Laboratory coats, tight woven dress clothing, and opaque gloves are all proper personnel protective equipment that may be needed depending on the operation. The LSO and PLU shall consult on the need for such protection based on the conditions under which the laser is in use.

Personal Protective Eyewear: Class 3b and 4 lasers shall require the use of protective eyewear within the hazard zone in which the MPE is exceeded; class 2 and 3R lasers may require eyewear depending upon the viewing options and duration of exposure. Eyewear shall be specifically labeled by the manufacturer with the appropriate wavelength and optical density for the laser in use. There are many factors to consider when selecting eyewear such as comfort, visible light transmission through the lens, angular dependence, and optical density (D_λ), just to name a few. Contact the manufacturer or the LSO for assist in the selection of eyewear.

Optical Density of Eyewear: D_λ is the logarithm to the base ten of the reciprocal of the transmittance at a specific wavelength.

$D_\lambda = \log_{10}(1/\tau_\lambda)$, where τ_λ = transmittance at the wavelength of interest.

$\tau_\lambda = (H_p/MPE)$, H_p = eye exposure level typically in units of W/cm^2, or J/cm^2.

The MPE determination is based on the duration of use, and particular wavelength. Recommended time factors are as follows:

(1) Aversion response to visible lasers (0.4 to 0.7 um, and class 3B and 4 lasers). The aversion response time of 0.25 s shall be used when long term intrabeam viewing is not intended.
(2) Near Infrared (0.7 to 1.4 um, and class 3B and 4 lasers). 10 s shall be used as a "worst case" time duration for MPE determination for this category of lasers.
(3) Diffuse Viewing (intended class 3B and 4). Maximum viewing times may be used within an 8 hour time period based on the operation, such as with alignment procedures where viewing is intended.
(4) Diffuse Viewing (unintended class 3B and 4). 600 seconds shall be used for this category of laser classes where there is potential for intense staring during an operation.
(5) Daily Occupational Exposure (long term, class 3B and 4). 30,000 s shall be used for long term 8 hour exposure durations to low level light where applicable.

Laboratory Window Protective Filters: Accessible windows into laboratory space in which class 3B and 4 lasers are in use may require shielding provided by filters or other suitable material in order to limit the level of emission outside the window to less than the MPE. The filter shall be labeled with appropriate wavelength and optical density capabilities.

Laser Protective Barriers and Curtains: A screen or curtain suitable to laser safety may be required in some laboratory setups in order to reduce the accessible emission levels to below the MPE in order to protect personnel in the laser controlled and uncontrolled areas of the lab. Typically an entire laboratory space is a laser controlled area since most if not all lasers have the capability to travel distances much greater than any dimension in the lab. "Suitable" refers to laser resistant in the case of light emission, any wavelength, and fire retardant if necessary. Barriers and curtains shall be labeled with appropriate wavelength and optical density capabilities.

Local Exhaust: In some cases local exhaust as well as controlled and enclosed exhaust systems may be necessary to remove unwanted laser generated air contaminants or for the control of lasing gases such as fluorine. The LSO and PLU shall consult with Occupational Safety and Health professionals for any assistance that may be needed in determining the necessity for such protective systems.

Laser Warning Signs

Lasers and laser systems shall have appropriate warning signs based on the hazard analysis and subsequent classification as Class 1, 1M, 2, 2M, 3R, 3B or 4. Appropriate "signal" words such as "Caution", "Danger", "Do Not Stare into Beam" and others shall be utilized to warn both trained and untrained personnel that may enter into areas where lasers or laser systems are in use. Referring to figure 1 and 2 below the standard laser warning sign shall be used for all laser facilities; "CAUTION" shall be used for Class 1, 1M, 2, 2M and 3A (below the applicable MPE); "DANGER" shall be used for Class 3R (output radiation > MPE), 3B and 4.

Referring to the signs on the following pages:

Position 1 above the tail of the laser starburst shall have the following:

• For Class 2: *"Laser Radiation - Do Not Stare into Beam."*

• For Class 2M and 3R: where the MPE is not exceeded for a 0.25 second exposure to visible wavelength region (0.4-0.7μm: *"Laser Radiation - Do Not Stare into Beam or View Directly with Optical Instruments."*

• For all other class 3R: *"Laser Radiation – Avoid Direct Eye Exposure to Beam."*

• For Class 3B: *"Laser Radiation – Avoid Direct Eye & Skin Exposure to Beam."*

• For Class 4: *"Laser Radiation – Avoid Eye or Skin Exposure to Direct or Scattered Radiation."*

Position 2 below the tail of the laser starburst shall have the following:

• For all Classes: type of laser, wavelength, pulse duration (if applicable) and maximum output.

Position 3 all signs shall have the Class of the laser or laser system.

Laser signs are available commercially or through the campus sign shop. Contact the LSO to determine the appropriate sign for your laser area.

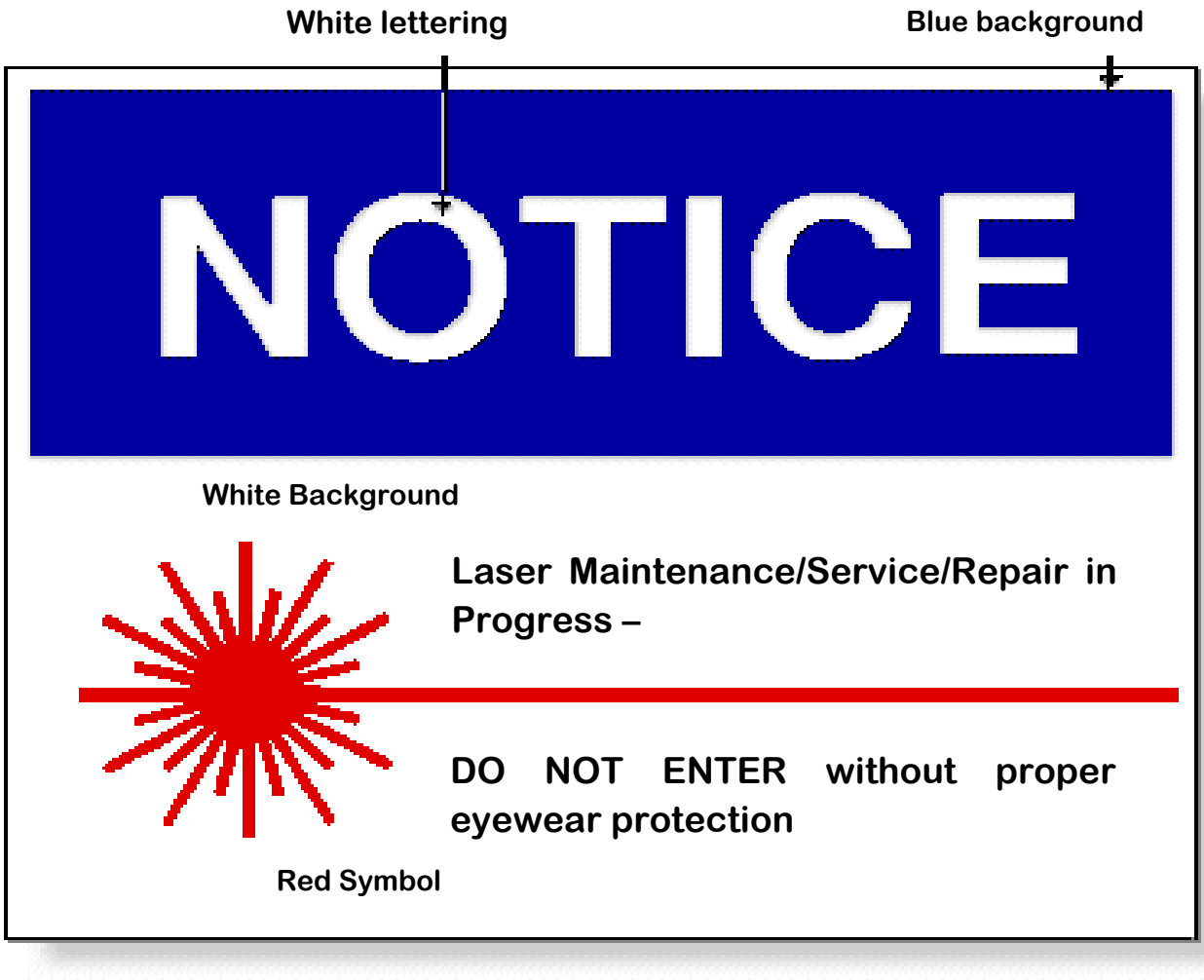

Figure 1: Required posting during maintenance/service/repair activities

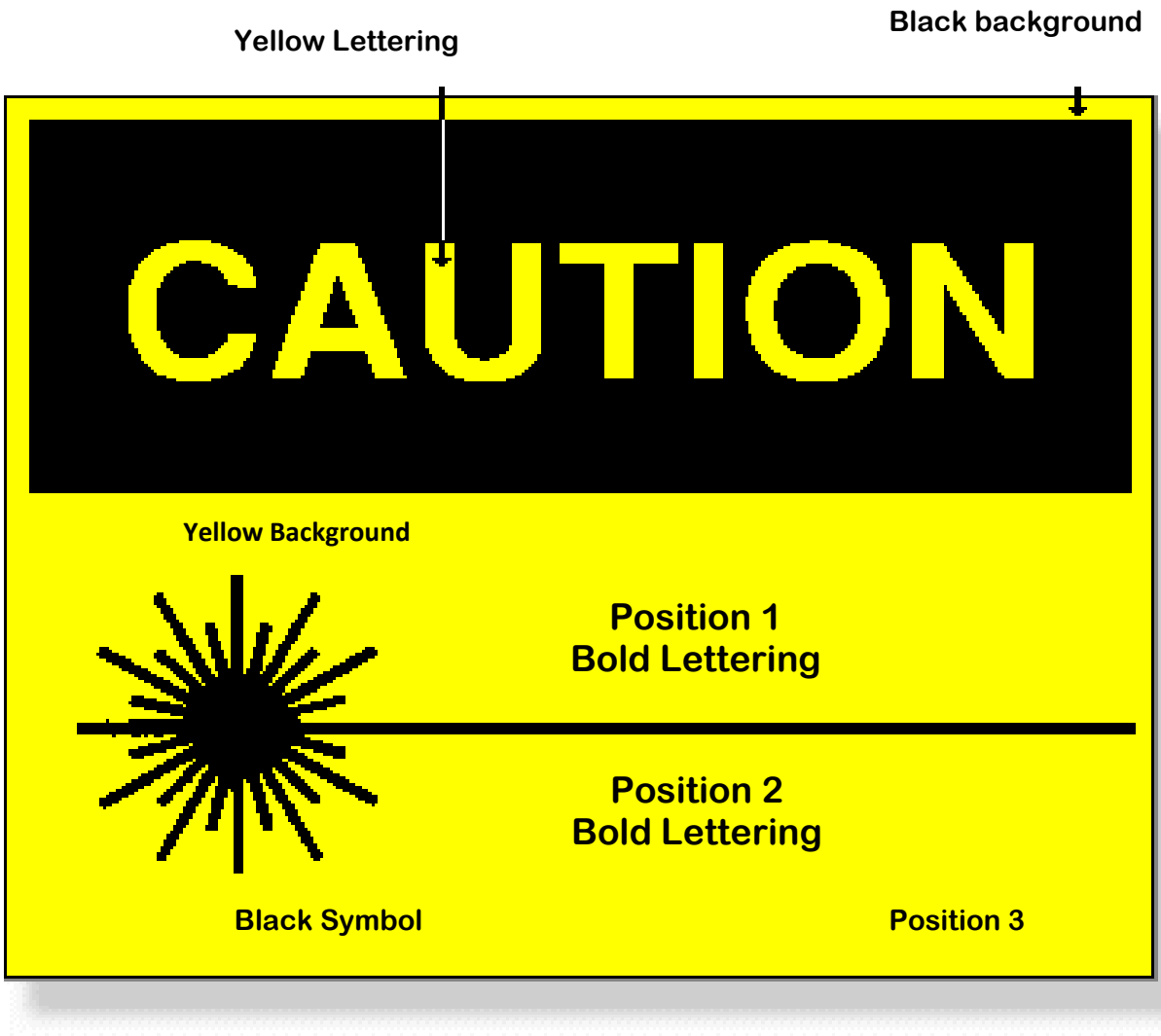

Figure 2: Caution sign for Class 1, 1M, 2, 2M and 3A (accessible radiation < MPE)

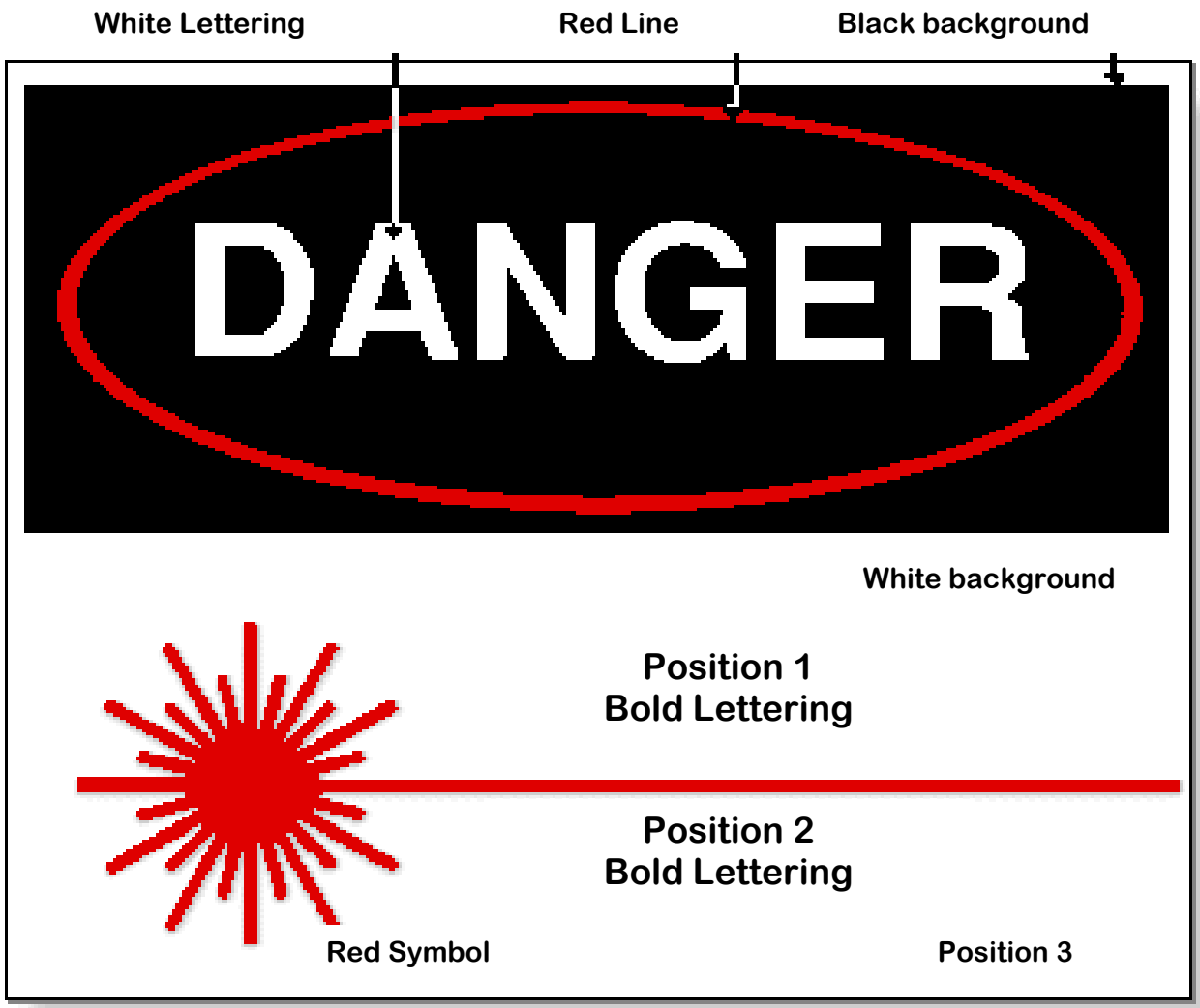

Figure 3: Danger sign for Class 3A (accessible radiation ≥ MPE), 3B and 4 lasers

Temporary Laser Warning Signs (Class 3R, 3B and4): Laser warning signs convey an immediate visual hazard recognition of potentially harmful laser light (Class 3R, 3B or 4), specific controls ("Eye wear required"), severity ("Avoid eye exposure"), and instructions ("Do Not Enter-while light is flashing"). In addition to standard signs such as those shown in Figures 1 through 3, temporary controlled laser area warning signs shall also be posted when applicable.

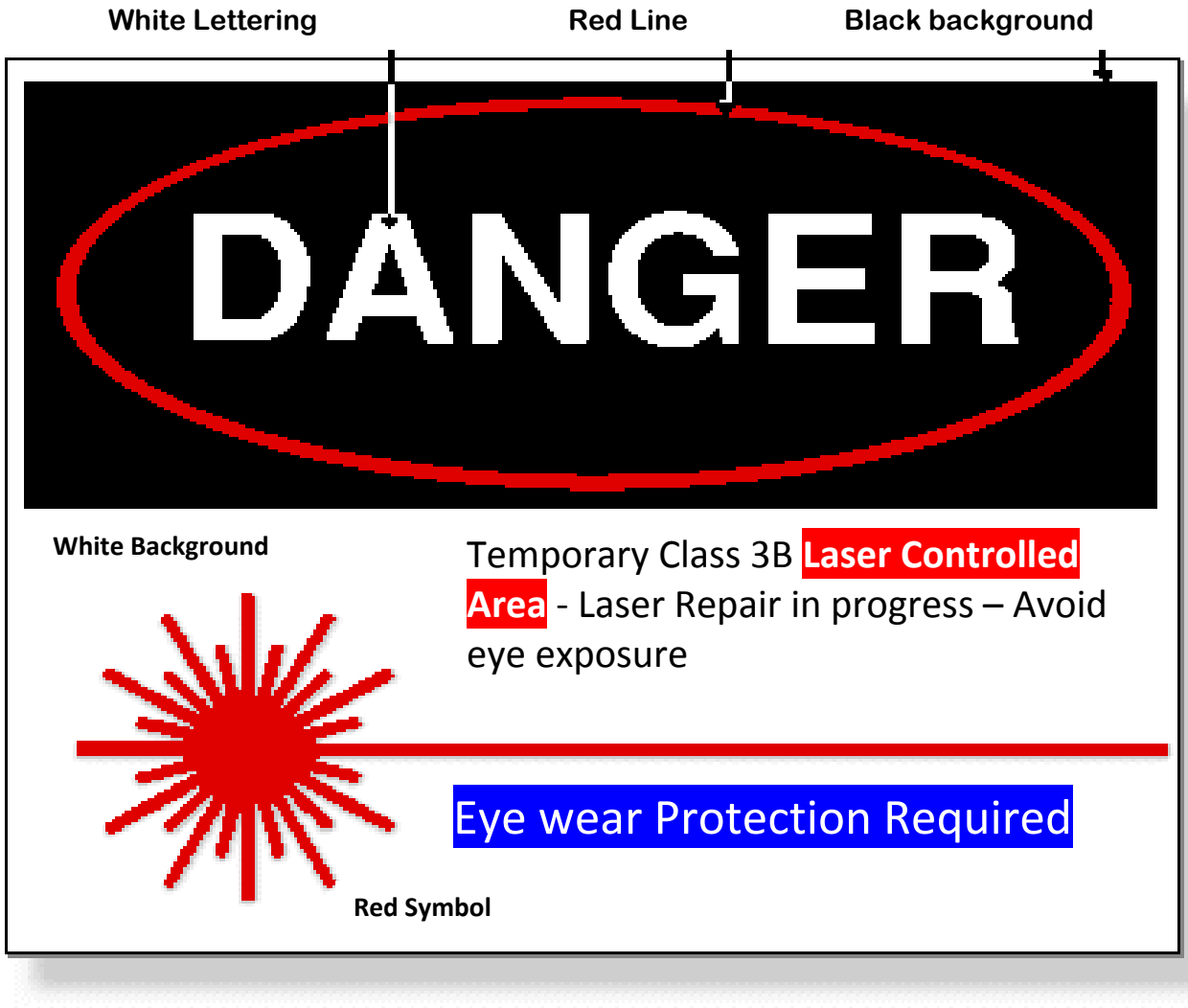

Figure 4 – Temporary Warning Sign requiring immediate hazard recognition

Engineering Controls

Engineering controls are required by the Federal Laser Product Performance Standard in the manufacturing and distribution of lasers and laser systems. Additional engineering controls may be applied by the end user in each area where lasers are utilized.

EC1. Protective Housing (All Classes): All classes of lasers require a protective housing. In some cases such as with embedded class 3B and 4 lasers, an interlock is required on the protective housing; this is also the case when the protective housing is removed temporarily such as with alignment (operational), and maintenance and service/repair. In these cases eyewear is almost always required as well as additional warning signs such as the NOTICE sign shown in figure 1. When it is proposed to defeat the protective housing control for any purpose, the LSO must conduct a Laser Hazard Analysis (LHA) in order to assess the exposure hazard and determine the appropriate eyewear to keep accessible radiation levels to within the Maximum Permissible Exposure for the laser in question and duration of procedure. Additional training shall be required for all personnel relative to the procedure which requires the removal of the protective housing controls.

EC2. Interlocks on Protective Housing (Class 3B or 4 or Embedded 3B or 4 lasers): Service/repair, alignment, walk-in laser systems, and removable protective housings all require interaction with an interlocking system to prevent hazardous exposure of personnel to laser light. Devices that prevent access to hazardous levels above the MPE include IR sensors at the threshold to the walk-in facility, floor mat sensors, electrical, mechanical and electromagnetic coupling devices that once tripped will close a shutter or immediately power down a laser. In most research cases this type of system would cause an interruption to an experiment and therefore is not frequently utilized; in this case it is required that the LSO determine if such an interlock mechanism *is* required or whether administrative controls and personal protective equipment (eyewear) are suitable replacements.

EC3. Bypass Interlock on Manufactured Protective Housing (Class 3B or 4 or Embedded 3B or 4 lasers): Interlocks provided by the manufacturer shall not be defeated without written permission of the LSO.

EC4. Service Access Panels (All Classes). These panels must always be interlocked unless removal is required by a qualified service expert.

EC5. Key Control (Class 3B or 4): Class 3B and 4 lasers should have a master switch key control to initiate emission of lasers light and reinitiate emission of laser light after shutdown or a failure which causes the system to de-energize or stop operating. The key may be removable after start up and must be held by the PLU or his/her appropriately trained and approved laser operator (LO). The PLU shall be required to notify the LSO in writing with the name of the LO that is responsible for the key.

EC6. Viewing Windows and Collecting Optics (All Classes): Must be interlocked to prevent or maintain permissible exposure levels to laser light at or below the MPE. Devices must be labeled according to manufacturer specifications with the threshold limits, optical density and wavelengths for which they apply.

EC7. Open Beam Path (Class 3B and4): The LSO shall effect a laser hazard assessment prior to any operation in which a Class 3B or 4 laser shall be operated in an open beam configuration. This applies to partially open beam or limited open beam configurations in which part of the experimental setup allows for access to the beam. In all cases the applicable MPE shall not be exceeded for the duration of the accessible emission of radiation to personnel.

EC8. Enclosed Beam Path (All Classes): Every effort should be made to enclose the beam path of a laser. For totally enclosed beam paths the classification changes to a class 1 laser. It may be necessary to label or place a warning sign on the enclosure depending on the capability of the enclosure to be interlocked to prevent accessible emission radiation levels above the applicable MPE limit. The LSO shall effect a laser hazard assessment regarding the enclosure and interlock relationship on all lasers and laser systems, homemade and manufactured to ensure the MPE limiting criteria are met.

EC9. Remote Interlock Connector (Class 3B and 4): Class 3B should and Class 4 lasers or lasers systems shall have a remote interlock connector to facilitate connections to an emergency master interlock disconnect which shall cause the accessible emission of laser light to be at or below the MPE. The master switch shall be readily accessible in one or more locations in the laser controlled area.

EC10. Beam Stop or Attenuator (Class 3B and 4): Class 3B and 4 lasers and laser systems shall have a beam stop or attenuator to limit the accessible emission limit at or below the applicable MPE, in particular when the output of the laser is not required during operation/maintenance/service or repair.

University of Maryland	Laser Classification						
Engineering Controls	1	1M	2	2M	3R	3B	4
Protective housing	**R**	**R**	**R**	**R**	**R**	**R**	**R**
Without protective housing	**LSO**						
Interlocks on protective housing	**SE**	**SE**	**SE**	**SE**	**R**	**R**	**R**
Service access panel	**SE**	**SE**	**SE**	**SE**	**SE**	**SE**	**R**
Key switch master						·	**R**
Viewing portals/Collecting Optics			**MPE**	**MPE**	**MPE**	**MPE**	**MPE**
Totally open beam path					**LSO**	**R**	**R**
Limited open beam path					**LSO**	**R**	**R**
Remote interlock connector					**LSO**	**R**	**R**
Beam stop or attenuator					**LSO**	**R**	**R**
Activation warning system						·	**R**
Emission delay							·
Class 3B laser controlled area						**R**	
Class 4 laser controlled area							**R**
Laser outdoor controls						**R**	**R**
Temporary laser controlled area	**SE**	**SE**	**SE**	**SE**	**SE**		
Remote firing & monitoring							·
Labels		**R**	**R**	**R**	**R**	**R**	**R**
Area posting			·	·	**LSO**	**R**	**R**
Administrative & procedural controls		**R**	**R**	**R**	**R**	**R**	**R**
Standard operating procedures						·	**R**
Output emission limitations					**LSO**		
Education and training					**LSO**	**R**	**R**
Approved Laser Operators						**R**	**R**
Alignment procedures			**R**	**R**	**R**	**R**	**R**
Eye protection					**LSO**	**R**	**R**
Spectator control						**R**	**R**
Service personnel	**SE**	**SE**	**SE**	**SE**	**SE**	**R**	**R**
Laser demonstration			**R**	**R**	**R**	**R**	**R**
Laser fiber optics			**R**	**R**	**R**	**R**	**R**

Key:
R Required
SE Shall If embedded Class 3R, 3B, 4
Blank Not Required
• Should
MPE Shall if MPE exceeded
LSO Determined by Laser Safety Officer

Figure 5 Engineering Controls Checklist

TRAINING

Training: Training is required for all personnel using class 3R, 3B and 4 lasers. Awareness training will be available for all personnel using class 1, 1M, 2, and 2M lasers. Training is commensurate with use and shall follow the guidance of ANSI Z.136.1 -2007 for the Safe Use of Lasers. DES is responsible for making laser safety training available through the Laser Safety Officer's list of responsibilities; the Principal Laser User is responsible for training their personnel onsite in the laboratory on the specific use and operation of the laser, including safety aspects of use and operation.

Initial Training Program: The following topics will be presented by the LSO in training users of class 3R, 3B, and 4 lasers:

(1) Fundamentals of laser operation;
(2) Bioeffects to eyes and skin;
(3) Specular versus Diffuse reflections;
(4) Laser classification;
(5) Control Measures, engineering and administrative;
(6) Personnel Protective Equipment, eyewear;
(7) Accidents and Incidents
(8) Non beam hazards.

Refresher Training Program: All personnel working with class 3B and 4 lasers shall be required to attend refresher training on an annual basis. The purpose of refresher training is to continue to make the laser user aware of the hazards associated with working with class 3B and 4 lasers. This is an abbreviated version of the initial training and covers any additional information in laser safety such as accidents that have occurred and lessons learned, since the initial training date.

Additional Information

Laser Pointers

Laser pointers shall be used only for the intention for which they were manufactured; this includes use by teachers as well as surveying, leveling and aligning lasers as well. Laser light from a pointer can be classified as a Class 1, 2 or even 3A and therefore must be used with caution when the classification exceeds the class 1 category. The potential hazard associated with these lasers is the same as other class 2 and class 3 hazards. NEVER direct a laser pointer output into another person's eye.

Laser Demonstration (experimental demonstrations): Approval for laser demonstrations and experimental demonstrations must be through the Principal Laser User and through the LSO for any general public demonstrations. Appropriate protection must be afforded all personnel present and the degree of hazard associated with the demonstration must be explained. The LSO in consultation with the Principal Laser User shall determine the allowed use of any laser outside the laser controlled area.

Optical Fiber Laser Transmission: Connected optical fiber systems are considered enclosed. If a cable is disconnected and the transmission exceeds the applicable MPE then controls must be put in place to prevent exposure to all personnel above the MPE level. Warning labels must be place on devices that indicated that the accessible levels of radiation will be present when cables are disconnected and the laser is still in operation.

Non Beam Hazards: Lasers are physical agents that can cause electric shock, sparking and ignition of flammable materials, as well as generate airborne contaminants, and cause fires. These non beam hazards will be addressed on a case by case basis with the University Fire Marshal and the DES Occupational Safety and Health staff when high powered lasers and high voltage systems are used in the lab. Compressed gases, laser dyes and solvents must also be used in a safe manner when utilizing laser or laser systems which contain these aspects of operation. All non beam parameters listed above must be reviewed by the LSO and the Principal Laser User in the hazard analysis performed for each laser operation. Specific non beam hazards must be addressed by the Principal Laser User as part of lab personnel training on the specific lasers and operations under their control.

Medical Surveillance: Medical surveillance shall be the responsibility of the Principal Laser User for his/her personnel in the lab. Any individual with an actual or suspected injury due to laser light should report to the Health Center or their physician as soon as possible after the actual or suspected exposure.

Emergencies, Accidents, and Revocation

Emergencies

A clearly marked "Emergency Stop" button or other actuating device shall be available and clearly marked for deactivating the laser output. Emergency Procedures must be posted and visible to the laser user.

Accident/Incident Investigation: Any accident or incident involving laser light shall be investigated by the LSO and reported to the Principal Laser User, and Radiation Safety Officer. The investigated laser or laser system shall not be utilized until the investigation is complete and the system is found to be safe for use again by personnel.