SUMMARY: Laser use at the University of Michigan (UM) encompasses many disciplines and applications. Due to the wide array of lasers and the potential hazards unique to each, OSEH has developed a Laser Safety Guideline which addresses work practices to be followed while working with lasers at the UM.

This Guideline should be used as a tool for laser users when developing a laser safety program. This program must be designed to protect all employees from potential hazards and meet federal, state and industry standards.

SCOPE: This Laser Safety Guideline applies to all UM departments and employees who actively use lasers in laboratories and other non-clinical University facilities.

REFERENCE REGULATIONS:
Laser Product Performance Standard (21 CFR 1040.10 and 1040.11)
American National Standard for Safe Use of Lasers (ANSI: Z136.1-2000)
Laboratory Safety Standard (Michigan Occupational Health Standards for General Industry R325.70101-325.70114)
General Duty Clause [29 FR 1910.5(a)(1)]
Lockout/Tagout, Control of Hazardous Energy Sources (Michigan Safety Standards for General Industry R408.18051-408.18502 Adoption by reference of 29 CFR 1910.147)
Construction Laser Standard - Non-ionizing Radiation (Michigan Occupational Health Standards for Construction Rule 6270 Part 682)

DEFINITIONS: *Light Amplification by Stimulated Emission of Radiation* (*Laser*) - a device that emits a coherent, directional beam of intense light by stimulating electronic or molecular transitions to lower energy levels. The spectrum of electromagnetic radiation ranges from the ultraviolet region through the visible to the infrared region. Laser radiation may be emitted as a continuous wave or as pulses.

(Table 1, 2, and 10 of American National Standard for Safe Use of Lasers ANSI Z136.1 – 2000 reproduced with permission from American National Standard for Safe Use of Lasers ANSI Z136.1 – 2000. Copyright 2000, Laser Institute of America, Orlando, Florida. The Laser Institute of America disclaims any responsibility or liability resulting from the placement and use in the described manner.)

Accessible Emission Limit (AEL) – The maximum accessible emission level permitted within a particular class. Refer to Appendix A for AEL tables.

Continuous Wave (cw) - the output of a laser that is operated in a continuous rather than a pulsed mode. A laser operating with a continuous output for a period >0.25 seconds is regarded as cw.

Class 1 Laser - cannot emit laser radiation in excess of the applicable Class 1 AEL. Class 1 lasers and laser systems are exempt from all control measures or other forms of surveillance with the exception of applicable requirements for embedded lasers.

Class 2 Laser - a low powered visible laser that em its accessible radiant energy exceeding the appropriate Class 1 AEL, but not exceeding radiant power levels above 1 m W. The human aversion response to bright light will protect most people from this class of laser.

Class 3a Laser – have an accessible output between 1 and 5 times the Class 1 AEL for wavelengths shorter than 0.4μm or longer than 0.7μm, or less than 5 times the class 2 AEL for wavelengths between 0.4 and 0.7μm.

Class 3b Laser –
(1) UV and infrared lasers that can emit accessible radiant power in excess of the Class 3a AEL, but
   a) cannot emit an average radiant power in excess of 0.5 W for ≥ 0.25s or
   b) cannot produce a radiant energy greater than 0.125 J within an exposure time < 0.25 s.
(2) Visible or near IR lasers that emit in excess of the AEL of Class 3a but
   a) cannot emit an average radiant power in excess of 0.5 W for ≥ 0.25s and
   b) cannot produce a radiant energy greater than 0.03 J per pulse.

Class 4 Laser - emit radiation that exceeds the Class 3b AEL.

Diffuse Reflections - change of the spatial distribu tion or "scattering" of a beam of radiation when it is reflected in many directions by a surface or medium.

Embedded Laser – An enclosed laser with an assigned class num ber higher than the inherent capability of the laser system in which it is incorporated, where the system's lower classification is appropriate due to the engineering features limiting accessible emission.

Infrared Radiation (IR) - a band of electrom agnetic radiation with wavelengths that lie between 0.7 um to 1 mm. The re gion is often broken up into near or far IR (dependent on the wavelength).

Laser Safety Officer (LSO) - enforces and m onitors the control of laser hazards. The principle investigator will serve as the LSO or will designate a LSO for his/her lab.

Maximum Permissible Exposure (MPE) - values established by ANSI for Safe Use of Lasers (see ANSI 2000 pp. 43-46 for MP E tables). The MPE is the level of laser radiation to which a person may be exposed without hazardous effects or adverse biological changes in the eye or skin.

Nominal Hazard Zone (NHZ) - the method for calculating the NHZ is established by ANSI for Safe Use of Lasers. The nominal hazard zone describes the space within which the level of the direct, reflected or scattered radiation during operation exceeds the applicable MPE. Exposure levels beyond the

boundary of the NHZ are below the appropriate MPE level. The LSO will calculate the NHZ and demarcate the zone within the lab.

Optical Density (OD) - the characteristic of safety glasses designed to protect the eye from laser radiation by attenuating laser light within the MPE for eye exposures. The required OD is the minimum OD necessary to reduce the beam to a non-hazardous level. The OD of eyewear has to be at least equal to or greater than the required OD. The OD can be calculated based on formulas in ANSI or can typically be found in the laser manufacturer's operations manual.

Standard Operating Procedure (SOP) - a concise document that gives safety instructions specific to the laser and associated equipment.

RESPONSIBILITY: Deans, Directors, and Department Heads

Designate and empower individuals who will be responsible for the preparation and implementation of the Laser Safety Guideline.

Actively support this Guideline within individual units.

Ensure an environment where Principal Investigators, Laser Safety Officers other personnel are encouraged to follow this Guideline.

Principle Investigators (PIs)

Designate a Laser Safety Officer (LSO) who will be responsible for the implementation of this Guideline and a ssure that all responsibilities of the LSO are carried out.

Principle Investigators (PIs) or Laser Safety Officers (LSOs)

Implement procedures in accordance with this Guideline.

Assure that staff is aware of this Guideline, instructed on the details of implementation, and provided with equipment and controls.

Conduct specific on-the-job training for all laser users and maintain documentation of this training.

Evaluate hazards of laser work areas and institute appropriate control measures.

Classify or verify classes of lasers in the laboratories.

Establish a Nominal Hazard Zone (NHZ) for each laser system if necessary, and demarcate the NHZ within the lab

Follow the "Supervisor's Guideline for Workplace Health" if there is an accident or injury.

Contact OSEH to request technical assistance.

Encourage the reporting of near misses and accident reporting to OSEH.

Purchase and provide correct laser personal protective equipment and engineering controls prior to laser system use.

Develop written Standard Operating Procedures (SOPs) for individual lasers and laser systems specifically outlining the setup, use, PPE and emergency response guidelines.

Laser Users

Comply with this Guideline, the SOPs, and any further safety recommendations initiated by Principle Investigator or LSO.

Conduct assigned tasks in a safe manner and wear appropriate personal protective equipment.

Report any job related injuries or illnesses, questions on health and safety, or any unsafe or unhealthy working conditions to the Principle Investigator or LSO.

May contact OSEH to evaluate health and safety conditions within their unit.

Only operate lasers and associated equipment for which they have been formally trained.

Consult the Principle Investigator or LSO whenever there are any questions regarding laser use.

OSEH

Review and revise the Laser Safety Guideline.

Provide baseline-training material to the LSO for use in developing site-specific training.

Provide technical assistance and conduct safety audits of compliance with ANSI program elements.

Serve as a university liaison for local, county, and state agencies regarding laser safety issues.

Document and administer the Prescription Safety Eyewear and Respiratory Protection Program.

Provide copies of state and federal regulations listed in the appendices of this Guideline upon request.

Review new laser facility construction and renovation projects.

PROCEDURES:

Minimum Laser Requirements For Laser Classes

Controls are to be followed for each of the four types of laser classifications. These controls are in accordance with the ANSI Z136.1-2000 and are provided in ANSI Table 10 below. Variance to these recommendations may occur, depending on site evaluation and use of the laser system (see ANSI Z136.1-2000 for further details).

For examples of appropriate "Caution" and "Danger" laser signs see Appendix B.

ANSI Table 10

Control Measures for the Four Laser Classes

Control Measures	Classification				
Engineering Controls	1	2	3a	3b	4
Protective Housing (4.3.1)	X	X	X	X	X
Without Protective Housing (4.3.1.1)	LSO shall establish Alternative Controls				
Interlocks on Protective Housing (4.3.2)	▽	▽	▽	X	X
Service Access Panel (4.3.3)	▽	▽	▽	X	X
Key Control (4..3.4)	—	—	—	•	X
Viewing Portals (4.3..5.1)	—	MPE	MPE	MPE	MPE
Collecting Optics (4.3.5.2)	MPE	MPE	MPE	MPE	MPE
Totally Open Beam Path (4.3.6.1)	—	—	—	X NHZ	X NHZ
Limited Open Beam Path (4.3.6.2)	—	—	—	X NHZ	X NHZ
Enclosed Beam Path (4.3.6.3)	None is required if 4.3.1 and 4.3.2 fulfilled				
Remote Interlock Connector (4.3.7)	—	—	—	•	X
Beam Stop or Attenuator (4.3.8)	—	—	—	•	X
Activation Warning Systems (4.3.9.4)	—	—	—	•	X
Emission Delay (4.3.9.1)	—	—	—	—	X
Indoor Laser Controlled Area (4.3.10)	—	—	—	X NHZ	X NHZ
Class 3b Indoor Laser Controlled Area (4.3.10.1)	—	—	—	X	—
Class 4 Laser Controlled Area (4.3.10.2)	—	—	—	—	X
Laser Outdoor Controls (4.3.11)	—	—	—	X NHZ	X NHZ
Laser in Navigable Airspace (4.3.11.2)	—	—	•	•	•
Temporary Laser Controlled Area (4.3.12)	▽ MPE	▽ MPE	▽ MPE	—	—
Remote Firing and Monitoring (4.3.13)	—	—	—	—	•
Labels (4.3.14 and 4.7)	X	X	X	X	X
Area Posting (4.3.9)	—	—	•	X NHZ	X NHZ

LEGEND
X - Shall
• - Should
— - No requirement
▽ - Shall if enclosed Class 3b or Class 4
MPE - Shall if MPE is exceeded
NHZ - Nominal Hazard Zone analysis required

ANSI Table 10 (cont.)

Control Measures for the Four Laser Classes

Control Measures	Classification				
Administrative and Procedural Controls	1	2	3a	3b	4
Standard Operating Procedures (4.4.1)	—	—	—	•	X
Output Emission Limitations (4.4.2)	—	—	LSO Determination		
Education and Training (4.4.3)	—	•	•	X	X
Authorized Personnel (4.4.4)	—	—	—	X	X
Alignment Procedures (4.4.5)	—	X	X	X	X
Protective Equipment (4.6)	—	—	—	•	X
Spectator (4.4.6)	—	—	—	•	X
Service Personnel (4.4.7)	▽ MPE	▽ MPE	▽ MPE	X	X
Demonstration with General Public (4.5.1)	MPE†	X	X	X	X
Laser Optical Fiber Systems (4.5.2)	MPE	MPE	MPE	X	X
Laser Robotic Installations (4.5.3)	—	—	—	X NHZ	X NHZ
Eye Protection (4.6.2)	—	—	—	• MPE	X MPE
Protective Windows (4.6.3)	—	—	—	X NHZ	X NHZ
Protective Barriers and Curtains (4.6.4)	—	—	—	•	•
Skin Protection (4.6.6)	—	—	—	X MPE	X MPE
Other Protective Equipment (4.6.7)	Use may be required				
Warning Signs and Labels (4.7) (Design Requirements)	—	•	•	X NHZ	X NHZ
Service and Repairs (4.4.7)	LSO Determination				
Modifications and Laser Systems (4.1.2)	LSO Determination				

LEGEND X - Shall
• - Should
— - No requirement
▽ - Shall if enclosed Class 3b or Class 4
MPE - Shall if MPE is exceeded
NHZ - Nominal Hazard Zone analysis required
† - Applicable only to UV and IR Lasers (4.5.1.2)

Training Required for Laser Operator

A. Baseline training material for operators, maintenance and service personnel is provided by OSEH to the LSO. This training consists of the following laser topics: fundamentals of laser operation (physical principles, construction, etc.), bioeffects of laser radiation on the eye and skin, significance of specular and diffuse reflections, non-beam hazards,

ionizing radiation hazards, laser/laser system classifications, control measures, overall responsibilities of management and employee, medical surveillance, and parts of this Guideline.

B. The Principal Investigator or LSO must give specific on-the-job training. This training must cover safe operating procedures, the SOPs, and any other specific safety information. The training must be documented for record-keeping purposes. These records may be kept in the Chemical Hygiene Plan (CHP), if applicable.

Training Required for Personnel Servicing or Working on Lasers with Exposed High Voltages and/or Capability of Producing Potentially Lethal Electric Currents

All electrical and other power sources will be shut down before work commences, and University of Michigan workers need Lock Out/Tag Out training, which is available through OSEH (http://www.oseh.umich.edu/pdf/guideline/loto_guideline.pdf).

Training Required for Laser Safety Officer or Principal Investigator

A. The LSO or PI must become familiar with the baseline training materials. They must also have knowledge of the following:
1. Laser terminology
2. Types of lasers, wavelengths, pulse shapes, modes, power/energy,
3. Basic radiometric units and measurement devices,
4. How to determine the Maximum Permissible Exposure (MPE) for eye and skin under all conditions,
5. How to perform laser hazard evaluations, range equations, and other calculations such as for Nominal Hazard Zone (NHZ).

B. LSOs should enroll in a laser safety r LSO course provided outside the University of Michigan for formal training. Some sources of training include: Laser Institute of America - http://www.laserinstitute.org/ and Rockwell Laser Industries - http://www.rli.com/

Periodic Inspection Requirements

The LSO shall conduct safety inspections on Class 3b and 4 lasers, associated equipment and facilities. Laser inspection guidelines are available on OSEH's website: http://www.oseh.umich.edu/pdf/lsrinspt.pdf.

All lasers and associated laser equipment found to be in poor condition or not meeting this Guideline shall be removed from service until properly repaired or re-designed.

OSEH will conduct safety audits of compliance with ANSI program elements.

Laser and Associated Equipment Servicing

The University's Lockout/Tagout, Control of Hazardous Energy Sources Program shall be followed whenever servicing or m aintenance of a laser occurs. Refer to:
http://www.oseh.umich.edu/pdf/guideline/loto_guideline.pdf

Medical Surveillance

Baseline eye examinations have been determined by the University Ophthalmology Department not to be necessary in order to later evaluate an acute laser eye injury. Therefore there is no preassignment medical requirement for laser users.

In the event of an injury, call MWorks (998-8788) during regular business hours. After hours, go to the University of Michigan Health System's emergency room. Where necessary, follow up evaluation will be conducted by an ophthalmologist.

Laser Protective Eyewear

Laser protective eyewear is required to be available and worn for Class 3b and Class 4 lasers and associated equipment.

Laser eyewear is designed to protect the eye from laser radiation by attenuating laser light within the MPE for eye exposures while allowing enough am bient light to be transmitted as not to pose a safety hazard. This characteristic of the laser lens is called optical density (OD). The OD varies for all types of lasers and is not only based on the type of laser but also on the operator's use of the eyewear. The OD of the eyewear must be specific to the laser being used and should not be interchanged with different types of lasers unless approved.

The PI or LSO will determine the appropriate personal protective equipment (PPE) used with the laser system. Manufacturer recommendations on the type of laser protective eyewear to be utilized are to be followed, if no modification or change to the laser system is performed by the operators.

Precautions While Performing Alignment Procedures

Studies have shown that most significant exposures to lasers have occurred during the alignment procedures. The following guidelines should be incorporated into the SOP for laser beam alignment:

Exclude unnecessary personnel and allow only trained employees to be present during alignment.

Assure that all emloyees present wear appropriate laser protective eyewear.

If possible, avoid using beam paths that are at sitting or standing eye level.

Where feasible, use a low power (Class 2 or 3a) visible laser to simulate the path of the high power and/or invisible lasers. If not, operate laser at lowest power possible for alignment.

Terminate laser beams and specular reflections with appropriate reflecting beam blocks.

Know how to use properly phosphor cards, IR viewers, video camera, or other beam display devices to locate low visibility beams (such as CO_2 and near IR laser systems).

Locate any specular reflections of the beam and block them as near their source as possible before proceeding to the next optical component or section.

Whenever possible, reduce all high power laser beams to the minimum possible power.

Use beam shutters to block high power beams any time they are not actually needed.

General Safety Guidelines [Required of all employees using Class 3a (when applicable), Class 3b and Class 4 lasers and associated equipment]

Where appropriate these guidelines should be included in the SOP so that the SOP becomes the one governing document that covers everything concerning laser safety.

All individuals working with or near a laser system shall be authorized to do so only by the PI or LSO.

Do not enter a room containing a laser unless authorized.

Be aware of laser related hazards (see Appendix D).

Before operating a laser, remove all jewelry and verify that all protective equipment and required control measures are in place and functional.

Ensure that Class 3a, 3b and 4 lasers cannot be energized inadvertently. Power shall be turned off when leaving the laser unattended. Capacitors are to be discharged by a manufacturers service representative or qualified electrician, if an inadvertent reactivation of the system is possible. A strong Lockout/Tagout program is critical to working safely with laser systems. The Lockout program should include specific information on deenergizing all potential hazardous energy sources. See IHS011 Lockout/Tagout Guideline noted in Related Documents section of this guideline.

Never look directly into the laser beam. Laser protective eyewear is to be worn during the operation of the laser and during beam alignment.

Beam alignment guidelines are to be performed at the lowest practical power levels.

Control laser use by some of the following methods: use of an interlock system, warning lights, placarding, locks on the access door, and barriers.

Enclose as much of the beam path as possible.

Observe good housekeeping practices within the laser area (i.e. keep area around table clear).

Position the beam path well above or below eye level whenever possible.

RELATED DOCUMENTS:

Lockout/Tagout Guideline
Personal Protective Equipment Guideline
Respiratory Protection Guideline

TECHNICAL ASSISTANCE:

All referenced guidelines, regulations, and other documents are available through OSEH (3-6973).

ATTACHMENTS:

Appendix A - Acceptable Exposure Limit Tables:
Appendix B - Types of ANSI approved laser signs
Appendix C - Suggested format for laser SOPs
Appendix D - Laser related hazards

APPENDIX A

ACCEPTABLE EXPOSURE LIMITS
ANSI Table 1

Accessible Emission Limits for Continuous-Wave Small-Source Lasers and Laser Systems*

Wavelength Range (μm)	Emission Duration (s)	Class 1 † (W)	Class 2 (W)	Class 3 § (W)	Class 4 (W)
Ultraviolet					
0.18 to 0.302	$3x10^4$	≤ 9.6×10^{-9}	—	>Class 1 but≤ 0.5	>0.5
0.302 to 0.4	$3x10^4$	≤ 3.2×10^{-6} depending on wavelength (see Table 5)	—		>0.5
Visible					
0.4 to 0.7	$10^{\dagger}$	≤ 0.4×10^{-3}	>Class 1 but ≤1×10^{-3}	>Class 2 but≤ 0.5	>0.5
Near Infrared					
0.7 to 1.05	≥10	≤ 0.4×10^{-3} to ≤ 1.9×10^{-3}	—	>Class 1 but≤ 0.5	>0.5
1.05 to 1.15	≥10	≤ 1.9×10^{-3}	—	>Class 1 but≤ 0.5	>0.5
1.15 to 1.2	≥10	≤ 1.9×10^{-3} to 1.5×10^{-2}			
1.2 to 1.4	≥10	1.5×10^{-2}			
Far Infrared					
1.4 to 100	>10	≤ 9.6×10^{-3}	—	>Class 1 but≤ 0.5	>0.5
Submillimeter					
$10^2 \times 10^3$	>10	≤ 9.5×10^{-2}	—	>Class 1 but≤ 0.5	>0.5

* Emission duration ≥ 0.25 s.

† When the design or intended use of the laser or laser system ensures personnel exposures of less than 10^4s in any 24-hour period, the limiting exposure duration may establish a higher exempt power level, as discussed in 3.2.3. The Class 1 AELs calculated with this standard, under certain circumstances, may not be equivalent to those calculated with FLPPS or the IEC standard.

§ For 1 to 5 mW CW laser systems (Class 3a) see 3.3.3.1 and 3.3.3.2.

NOTE: The wavelength range λ_1 to λ_2 means $\lambda \leq \lambda < \lambda_2$, e.g., 0.18 to 0.4 μm means $0.18 \lambda \leq \lambda < \lambda$ 0.4 μm.

ANSI Table 2

Accessible Emission Levels (Radiant Energy)
for Single-Pulse laser and Laser System Classification*

Wavelength Range (μm)	Emission Duration** (s)	Class 1 (J)	Class 3b (J)	Class 4 (J)
Ultraviolet				
0.18 to 0.302†	10^{-9} to 0.25	≤ 2.4 x 10^{-5}	>Class 1 but ≤ 0.125	>0.125
0.302 to 0.4	10^{-9} to 0.25	≤ 2.4 x 10^{-5}	>Class 1 but ≤ 0.125	>0.125
		≤ 3.1 x 10^{-3}	>Class 1 but ≤ 0.125	>0.125
Visible				
0.4 to 0.7	10^{-9} to 0.25	≤ 0.2 x 10^{-6}	>Class 2 but ≤ 0.3	>0.03
		≤ 0.25 x 10^{-3}	>Class 2 but ≤ 0.3	>0.03
Near Infrared				
0.7 to 1.05	10^{-9} to 0.25	≤ 1.9x 10^{-7} to ≤ 1.2 x 10^{-3}	>Class 1 but ≤ 0.03 C_A	>0.03 C_A***
1.05 to 1.4	10^{-9} to 0.25	≤ 1.9x 10^{-6} to ≤ 9.8 x 10^{-3}	>Class 1 but ≤ 0.125	>0.125
Far Infrared				
1.4 to 10^2	10^{-9} to 0.25	≤ 79x 10^{-6} to ≤ 7.9 x 10^{-3}	>Class 1 but ≤ 0.125	>0.125
Submillimeter				
10^2 x 10^3	10^{-9} to 5x10^{-6}	≤ 0.01 to 0.025	>Class 1 but ≤ 0.125	>0.125
	5x10^{-6} to 0.25	≤ 0.025 to ≤ 0.38	>Class 1 but ≤ 5 x Class 1	

* There are no Class 2 single-pulse lasers.

** See note in Section 8 for pulse widths less than 1 ns.

† Wavelength dependent (see Table 5).

*** For 1 to 5 mW CW laser systems (Class 3a) see 3.3.3.1 and 3.3.3.2.

NOTE: The wavelength range λ_1 to λ_2 means $\lambda \leq \lambda < \lambda_2$, e.g., 0.18 to 0.4 μm means 0.18 $\lambda \leq \lambda <$ λ 0.4 μm.

APPENDIX B

TYPES OF ANSI APPROVED LASER SAFETY SIGNS

http://www.oseh.umich.edu/lasersin.html

APPENDIX C

SUGGESTED FORMAT FOR LASER STANDARD OPERATING PROCEDURE (SOP)

The ANSI Z136.1 recommends written SOPs for activities involving Class 3b lasers, and requires written SOPs for Class 4 lasers and laser systems. A SOP should be a concise document that gives safety instructions specific to the laser and associated equipment.

Laser Identification & Characteristics

Department_____ Room _____
Primary Investigator_____

Laser Type_____ Laser Class_____
Manufacturer_____
Maximum Power (Watts)_____ Maximum Energy (Joules)_____
Operational Wavelengths (nm)_____ Beam Size @ aperture (mm)_____
Chose one: continuous wave____ single pulsed <1 Hz____ repetitively pulsed >1 Hz ____
The calculated Nominal Hazard Zone for this laser is:_____
and the area of the NHZ has been demarcated.

2. Hazards associated with this laser *(check all that apply)*:
Eye ____
Skin ____
Electrical ____
Air contaminants ____
Other ____ Please describe:_____

3. Control Measures. For each hazard listed above briefly state the control measures to be used.

Specific type of eye and/or skin protection used _____
Description of entryway controls _____
Reference to equipment manuals _____
NHZ procedures:_____
Shutdown procedures_____
Other controls in place_____

Alignment Procedures for this Laser *(see procedures section of OSEH Guideline for assistance*)
(*list here or attach)*

De-energization procedures when working on exposed electrical parts *(see OSEH Lockout/Tagout Guideline for assistance)*
(list here or attach)

4. Training Requirements. All users of this laser must first received the following training:

OSEH Laser safety training and
_____(*note lab specific training here)*

All training for this laser is provided by: _____

5. Emergency Procedures. List actions to be taken in case of emergency and personnel to be contacted.

_____
_____
_____

6. Approved Personnel. List all individuals who are approved to operate the laser without supervision.

_____ _____
_____ _____
_____ _____

Note: A hazard evaluation is also required by ANSI for Class 3b and 4 lasers and associated equipment. This should be kept on file or attached to your SOP.

APPENDIX D

LASER RELATED HAZARDS

Personal Exposure

In the event an employee is exposed to laser light, a portion of that light can be absorbed into the body tissues causing injuries of varying degree. If the intensity of the laser beam is strong enough, irreversible injury to both the eye and skin can be experienced.

Eye: Corneal or retinal damage is possible from acute and chronic exposure to laser radiation. The extent of the damage is dependent upon the wavelength, power and duration of the laser. The cornea is more susceptible to damage from exposure to short-wavelength ultraviolet light due to its absorption properties. Longer ultraviolet wavelengths, the visible spectrum, and the near infrared affect them or sensitive retinal portion of the eye. Near infrared radiation is absorbed, to some degree, by all the structures of the eye (cornea, lens, eye fluids, and retina) and can be hazardous to all. Eye hazards are easily controlled with the use of appropriate safety eyewear, appropriate engineering controls, and strict implementation of administrative controls.

Skin: Severe skin burns are possible from acute exposure to high levels of laser radiation in the infrared region. Erythema (sunburn), skin cancer, and accelerated skin aging are possible with long-term exposure to laser radiation in the ultraviolet radiation bands.

Electrical

Most serious injuries and fatalities are associated with electrical/high voltage components of lasers. High voltage power supplies required for pulsed and continuous wave class 4 lasers present the most significant high voltage electrical hazard.

The University's Lockout/Tagout, Control of Hazardous Energy Sources Program shall be followed whenever servicing or maintenance of a laser occurs.

Special precautions shall be taken if you must service equipment without de-energizing it. Employees performing these activities must be trained and qualified in working with exposed energized parts.

Chemical Hazards

Media used to stimulate laser radiation (excimer, dye, chemical lasers) may be toxic or hazardous substances. In addition the generation of harmful gasses, vapors or particles as by-products associated with burning metals and polymers may present significant health hazards.

Hazardous chemical and gas use is common within laser laboratories. In compliance with the Laboratory Safety Standard (MIOSHA R325.70101-70114), all personnel shall be trained on correct safety practices when handling potentially hazardous chemicals and gasses. The proper handling and storage of gas cylinders is necessary to prevent serious physical injury. Examples of types of chemicals and gases known to be hazardous include chlorine gas, fluorine gas, and some laser dyes. Some gases such as argon and carbon dioxide may not be as toxic as others used, but can displace oxygen in enclosed areas. Additionally, chemicals and materials that are used as lasing mediums may require the installation of special controls due to the generation of hazardous off gassing components. Information regarding these materials and the handling of them is available through OSEH.

Fire Hazards

Use of flammable materials in conjunction with high- powered lasers increases the potential of a fire hazard.

Class 4 lasers by definition are considered fire hazards. Flammable materials and substances within an area containing a Class 4 laser must be placed outside the nominal hazard zone. Reflective surfaces are to be painted with non-reflective paint in order to avoid a fire hazard due to unintended beam reflections.

Laser Cutters

Laser cutters operate by directing large amounts of energy onto a very small surface area of a material. This elevates the temperature of the material very rapidly to a point where it melts or evaporates, creating laser generated air contaminants. Local exhaust ventilation may be necessary to capture and remove the contaminants from the work area. Contact OSEH for help in determining whether or not the contaminants generated by a particular application will pose a health hazard.