UAH

The University of Alabama in Huntsville

LASER SAFETY MANUAL

Office of Environmental Health and Safety
Facilities and Operations Department
The University of Alabama in Huntsville
Huntsville, AL 35899

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2014 Rev. 2

Table of Contents

REVIEW DATES FOR THE UAH LASER SAFETY MANUAL

UAH OEHS quality control guidelines for safety programs require that this Plan be reviewed and evaluated at least once every two years from the date of the original Laser Safety Manual. The Director of Environmental Health and Safety and the Director of the Center for Applied Optics must conduct the review. The review dates are documented below.

Review Date	**Revision No.**	**Reviewing Party Printed/Typed Name/Title**	**Reviewing Party Signature**
1999	Original Plan	Randy Wright/Director -OEHS	
		Dr. John Dimmock/Director - CAO	
07/2002	1	Marcia Green/Director – OEHS	
07/2002	1	Dr. John Dimmock/Director - CAO	
08/2014	2	Marcia Pendleton/Director - OEHS	

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THE UNIVERSITY OF ALABAMA IN HUNTSVILLE
LASER SAFETY POLICY STATEMENT

All University Departments, Research Centers and/or Laboratories utilizing non-ionizing radiation devices, including lasers and microwaves, are required to be familiar and comply with all procedures found within the UAH Laser Safety Manual. Each unit using such devices shall establish appropriate standard operating procedures, using the Laser Safety Plan template provided in Appendix C, addressing usage, control, and safety exposures involved.

The following procedures relating directly to the use of lasers shall be established. These procedures include, but are not limited to:

1. Use of basic personal protection, including eye protection for users and observers.
2. Training of employees and students in the proper use and safe handling of these devices.
3. Required registration of class IIB and IV lasers with the UAH OEHS on the New Lab Start Up form and or the Project Registration. (Standard laser copiers, laser printers, optical scanners, or equivalent devices will be assumed to be Class I lasers and will be exempt from filing a Laser Safety Plan.)
4. Labeling of all laser equipment with applicable Class, Wavelength, and Power.
5. Posting appropriate hazard warning signs in areas where lasers are used and a risk of injury is present.
6. Control of access to areas where Class IV lasers are in use.
7. Reporting incidents or accidents involving laser devices.
8. Authority for the UAH Lab Safety Committee to establish and revise policies, programs, and procedures relating to the UAH Laser Safety Program.

It shall be the responsibility of the Laser Safety Officer to monitor the compliance with procedures established within the UAH Laser Safety Manual and the device/site specific Laser Safety Plan.

No unit or individual within the University may install or operate a laser unless a Laser Safety Plan (LSP) has been approved by the Laboratory Safety Committee (LSC). Once granted, the approval remains in force until withdrawn by request of the applicant or upon notification by the LSC. Alterations (moves, etc.) that may necessitate a change in the LSP for a specific area/device must be approved through either revision of the current plan or submittal of a new LSP.

DISCLAIMER

This Laser Safety Manual was prepared for use on The University of Alabama in Huntsville (UAH) campus. It is provided as a means of presenting the regulations and standards pertaining to laser safety and as a guideline to illustrate standard, accepted practices for the safe use of lasers and laser systems. Neither the author nor the University of Alabama in Huntsville warrants its completeness or correctness.

Preface

Laboratories and research facilities require precautions to limit hazards associated with their day-to-day work. Laboratories with lasers require special safety procedures to ensure a safe environment.

This manual describes reasonable and necessary policies and procedures for the safe use of lasers and applies to any and all departments, research centers, and laboratories that are associated in any manner with the use/handling of lasers at UAH.

The safety standards contained in this manual are based primarily on the American National Standards Institute "Guide for the Safe Use of Lasers" (ANSI Zl36.1). The guide represents the generally accepted standards for the safe use of lasers within the fields of industry, education, research, and medicine.

1.0 Introduction

Lasers currently in use at The University of Alabama in Huntsville present a variety of potentially serious hazards. Laser radiation can cause injury to the eyes and skin. Lethal electrical and fire hazards can also be present with certain high-powered lasers. In addition, various hazardous chemicals may be present, in use, and may be developed as a result of laser use. These hazardous chemicals may pose a threat in certain interactions with the laser.

Each University unit operating lasers or laser systems will provide documentation, in the form of standard operating procedures (SOPs), to the OEHS stating that the appropriate control measures are implemented to reduce the possibility of exposure to laser associated hazards as specified in this manual. The OEHS provides this information to the Lab Safety Committee for review, comment and recommendations.

Each University Unit operating lasers and laser systems is responsible for the purchase of controls recommended by ANSI Z136 and accepted as general industry guidelines to insure the safety of the users, occupants, the facility and the environment.

2.0 Scope

This manual applies to all lasers used in research and instructional labs at the University of Alabama in Huntsville.

3.0 Responsibilities

A. Principal Investigators are responsible for:

- Supervising laser use in the laboratory.
- Implementing and enforcing the safety recommendations and requirements outlined in this manual.
- Developing standard operating procedures (SOPs) for the laboratory.
- Providing laser operators with training in operating, administrative and alignment procedures.
- Ensuring that all lasers in the laboratory are properly classified and labeled.
- Ensuring that the proper signs are posted at the entrance(s) to the laboratory.
- Registering all lasers with the Office of Environmental Health and Radiation Safety (EHRS).
- Attending laser safety training.
- Registering for the medical surveillance program if working with Class 3b or Class 4 lasers.
- Notifying EHRS immediately in the event of an exposure to a Class 3b or Class 4 laser beam or reflection.

B. Laser Operators are responsible for:

- Following laboratory standard operating procedures (SOPs).
- Informing the Principal Investigator of any departure from the SOPs.
- Notifying the Principal Investigator in the event of an exposure incident.
- Attending laser safety training.
- Registering for the medical surveillance program if working with Class 3b or Class 4 lasers.

C. The Laser Safety Officer (LSO) is responsible for:

- Conducting safety audits of all laser laboratories.
    - effect or complete a hazard evaluation
    - confirm the classification of lasers
    - assure proper control measures are in place or approve substitute controls
    - approve site-specific standard operating procedures
    - recommend and or approve eyewear and other protective equipment
    - assure appropriate signs and labels are used
    - approve laser facility controls
- Providing assistance in evaluating and controlling hazards.
- Review the Laser Safety Manual annually and as required.
- Maintenance of laser safety audit and use records.
- Conduct laser safety training for all personnel working with lasers.
- Participate in accident investigations involving lasers.

4.0 Laser Classifications

The intent of laser hazard classification is to provide warning to users by identifying the potential hazards associated with the corresponding levels of accessible laser radiation through the use of labels and instruction. It also serves as a basis for defining appropriate control measures and medical surveillance that will be discussed in later sections.

Lasers and laser systems are required to be appropriately labeled by the manufacturer in conformance with the Federal Laser Product Performance Standard. In most cases, this class label will determine the laser classification for the purpose of the Laser Safety Plan unless the LSO determines that there are special considerations that require the laser to be reclassified.

All lasers can be classified into one of four major categories. The basis of the classification scheme is the ability of the primary or reflected beam to cause biological damage to the eye or skin during use. The criteria are established based upon the Maximum Permissible Exposure (MPE) levels that are accessible during operation of the laser.

Class I

A Class I laser is considered safe based on current medical knowledge. This class includes all lasers or laser systems, which cannot emit levels of optical radiation above the exposure limits for the eye under any exposure conditions inherent in the design of the laser product. There may be a more hazardous laser embedded in the enclosure of a Class I product, but no harmful radiation can escape the enclosure.

Class II

A Class II laser or laser system must emit a visible laser beam. Because of its brightness, Class II laser light will be too dazzling to stare into for extended periods. Momentary viewing is not considered hazardous since the upper radiant power limit on this type of device is less than the MPE for the momentary exposure of 0.25 seconds or less. Intentional extended viewing, however, is considered hazardous.

Class III

A Class III laser or laser system can emit any wavelength, but it cannot produce a diffuse reflection hazard unless focused or viewed for extended periods at close range. It is also not considered a fire hazard or serious skin hazard. Any continuous wave (CW) laser that is not Class I or Class II is a Class III device if its output power is 0.5 W or less. Since the output beam of such a laser is definitely hazardous for intrabeam viewing, control measures center on eliminating this possibility.

Class IV

A Class IV laser or laser system is any laser that exceeds the output limits (Accessible Emission Limits or AEL'S) of a Class III device. As would be expected, these lasers may either be a fire, skin or a diffuse reflection hazard. Very stringent control measures are required for a Class IV laser or laser system.

5.0 Types of Hazards

Lasers produce an intense, highly directional beam of light. If directed, reflected, or focused upon an object, laser light will be partially absorbed, raising the temperature of the surface and/or the interior of the object, potentially causing an alteration or deformation of the material. These properties, which have been applied to laser surgery and materials processing, can also cause tissue damage. In addition to these obvious thermal effects upon tissue, there can also be photochemical effects when the wavelength of the laser radiation is sufficiently short, i.e., in the ultraviolet or blue region of the light spectrum.

5.1 Eye and Skin Hazards

The human body is vulnerable to the output of certain lasers, and under certain circumstances exposure can result in damage to the eye or the skin. It is now widely accepted that the human eye is almost always more vulnerable to injury than the human skin. The following are some examples of laser hazards and how/where they can affect the eye:

- Radiations at the visible and near-infrared wavelengths are absorbed and can have hazardous effects on the retina.
- Radiations at the near ultraviolet and middle infrared wavelengths are absorbed and can damage the eye lens.
- Corneal absorption and associated effects can occur with far-infrared and middle-ultraviolet wavelengths.
- Corneal lesions and retinal lesions can occur from the heat resulting from the energy absorption and from photochemical reactions.
- Eye contact within some transitional wavelength zones can result in both corneal and retinal damages.

Laser exposure in the retinal hazard region, approximately 400nm (violet light) to 1400nm (near infrared) of the optical spectrum, is of greatest concern. This includes the entire visible portion of the optical spectrum. Within this spectral region, collimated laser rays are brought to focus on a very tiny spot on the retina and may under optimum conditions be concentrated by a factor of 100,000 times at this point, although less frequent, the potential for injuries resulting from skin exposure to a laser beam should be treated just as strictly as the potential for eye injuries. In certain situations where eye protection is worn, skin exposure could represent a higher level of danger and must be guarded against.

“It should be noted that personal protective equipment may have serious limitations when used as the only control measure with higher power Class IV lasers or laser systems; the protective equipment may not adequately reduce or eliminate the hazard, and may be damaged by the incident laser radiation” (ANSI Z136.1, 2000). Eye protection must be designed to afford the maximum feasible protection and be worn at all times.

6.0 Associated Non-Beam Hazards

In addition to the direct hazards to the eye and skin from the laser beam itself, it is also important to address other hazards associated with the use of lasers. The ancillary hazards of electrical shock, fire, and injuries from cryogenics and chemicals are all potential health and life threatening problems associated with the use of lasers.

6.1 Electrical Hazards

Next to skin and eye exposures, electrical shock represents the highest potential for injuries from laser use, especially with the newer, high-powered lasers. The potential for electrical hazards most commonly results from inappropriate electrical installation, grounding, or handling of the high voltage associated with many lasers. Any University unit responsible for the operation of any laser shall ensure the necessary protective electrical circuit design. The laser resonator and electro-optical elements should also be designed so that no exposed metallic element is above ground potential. All electrical installations must comply with applicable code and product requirements.

6.2 Fire and Explosion Hazards

High-pressure arc lamps, filament lamps, and associated optics can shatter or explode during laser operation. These components must be enclosed in housings that can withstand the maximum explosive pressures. The proper installation of the electrical power supply discussed in the above section is also important to reduce the potential for electrical fire. Any enclosures, barriers or baffles must comply with UL Standard 746C, "Polymeric Materials for Use in Electrical Equipment".

6.3 Other Associated Hazards

Consideration must be given to other hazards that may be associated with laser use, including the presence of compressed gases (e.g. excimer gas lasers), dyes, cryogenic liquids, toxic fumes and gases, ionizing radiation, and toxic materials/chemicals. Consideration should also be given to the proper disposal of any hazardous material/waste in accordance with the UAH Hazardous Waste Management Plan.

7.0 Laser Hazard Evaluation

In considering the evaluation of hazards associated with lasers, three aspects of the application of a laser or laser system influence the total hazard evaluation:

1. The laser or laser system's ability to injure personnel
2. The environment in which the laser is used
3. The personnel who may use or be exposed to the beam

All three aspects must be considered in order to establish control measures commensurate with the potential hazard when developing a Laser Safety Plan for your laboratory.

8.0 Safety and Control Measures

The environment in which the laser is used may vary with each application and may therefore affect the hazard potential of the instrument. It is extremely important, therefore, that the environment in which the laser is used be considered in order to determine whether or not the control measures are adequate, or possibly some measures are unnecessary. As a minimum, during a hazard evaluation, the following must be considered:

1. Number of lasers or laser systems
2. Degree of isolation (laboratory security, etc.)
3. Probability of the presence of uninformed, unprotected transient personnel (custodians, students, maintenance, etc.)
4. Permanence of beam path(s)
5. Permanence of specularly reflecting objects in or near the beam path
6. The use of optics (e.g., lenses, microscopes, optical fibers)

Control measures shall be devised to reduce the possibility of exposure of the eye and skin to hazardous laser radiation and to other hazards associated with the operation of lasers and laser systems. This applies during normal operation and maintenance by users, as well as alignment and servicing of lasers and laser systems.

There are two basic categories of controls useful in laser environments. These are Engineering Controls and Administrative and Procedural Controls including Personal Protective Equipment. The controls to be reviewed in this manual are based upon recommendations of the ANSI Z-136.1 standard.

8.1 Engineering Safety and Control Measures

Based upon the laser classification and the hazard evaluation, certain safety and control measures will most likely be required. The LSO will review all control measures as defined in the units Laser Safety Plan to determine whether or not the measures are adequate. These measures may include engineering control measures incorporated into the laser or laser system, such as, but not limited to:

- protective housings
- access panels
- master switches
- viewing portals
- open or enclosed beam paths

8.2 Administrative and Procedural Control Measures

Certain areas may require administrative and procedural controls that supplement and/or implement engineering control measures. These administrative and procedural controls are the responsibility of the responsible party and include, but are not limited to:

- standard operating procedures (Laser Safety Plan)
- laser hazard and safety training for faculty, staff, and students
- authorized personnel requirements
- required alignment procedures
- required eye and skin protection
- notification of the presence/usage of any hazardous materials and their proper handling and disposal

9.0 Specific Engineering Controls

There are some uses of Class IIIB and IV lasers where the entire beam path may be totally enclosed, other uses where the beam path is confined by design to significantly limit access, and yet other uses where the beam path is totally open. In each case, the controls required will vary as follows:

9.1 Enclosed (Total) Beam Path:

Perhaps the most common form of Class I laser system is a high power laser that has been totally enclosed (embedded) inside a protective enclosure equipped with appropriate interlocks and/or labels on all removable panels or access doors. Therefore, beam access is prevented during operation and maintenance.

Such a completely enclosed system, if properly labeled and properly safeguarded with protective housing interlocks (and all other applicable engineering controls), will fulfill all requirements for a Class I laser and may be operated in the enclosed manner with no additional controls for the operator.

During periods of service or maintenance, controls appropriate to the class of the embedded laser may be required (on a temporary basis) when the beam enclosures are removed and beam access is possible.

9.2 Limited Open Beam Path:

Certain industrial processing lasers have an enclosure that surrounds the area around the laser focusing optics and encloses the immediate area of the workstation almost completely. Often, a computer controlled positioning table is located within such areas.

Such a system does not meet the stringent "human access" requirements for a Class I laser, but the real hazards are well confined.

Such a design provides what is called a limited open beam path. In this situation, a hazard analysis must be conducted and must be submitted with a detailed Laser Safety Plan to the LSO. Training will also be required commensurate with the class of embedded laser.

Protective equipment (eye protection, temporary barriers, clothing and/or gloves, respirators, etc.) will be required if the hazard analysis indicates a need or if the Laser Safety Plan requires periods of beam access during setup, adjustment, or maintenance. Temporary control measures must be handled in a manner similar to that of any embedded Class IV laser.

9.3 Totally Unenclosed Beam Path:

Applications where high power (Class IIIB and Class IV) lasers are used in an unenclosed beam condition will require that the unit supervisor complete a hazard analysis and assessment. Following this assessment and the development of a Laser Safety Plan, the controls implemented will reflect the magnitude and extent of hazards associated with the accessible beam.

10.0 Laser Controlled Area

When the entire beam path from a Class IIIB or Class IV laser is not sufficiently enclosed and/or baffled such that access to radiation above the Maximum Permissible Exposure (MPE), Appendix A, a "Laser Controlled Area" is required. The laser controlled area shall be defined in the SOP. During periods of usage, a controlled area may be established on a temporary basis. The controlled area will encompass the entire hazard zone. Those controls required for both Class IIIB and Class IV lasers are as follows:

10.1 Posting with Appropriate Laser Warning Signs:

Class IIIA (Beam Irradiance of 2.5 MW/CM^2), Class IIIB and Class IV lasers require the Danger sign format: white background, red laser symbol with black outline and black lettering (see Appendix B).

Class II or Class IIIA areas are to be posted with the caution format: yellow background, black symbol and letters.

10.2 Operated by Qualified and Authorized Personnel:

Operators of all Class IIIB and Class IV lasers are required to receive training appropriate for such lasers including laser safety as specified in Section 13.0 of this manual.

10.3 Transmission from Indoor Controlled Area:

The beams shall not, under any circumstances, be transmitted from an indoor laser controlled area unless for specific purposes (such as testing). In such cases, the operator must assure that the beam path is limited to controlled air space.

11.0 Class IV Laser Controls - General Requirements

Items recommended for Class IIIB and required for Class IV lasers (areas) are as follows:

1. Supervised directly by an individual knowledgeable in laser safety and approved by the PI.
2. Require approved entry of any non-involved personnel by the PI.
3. Terminate all potentially hazardous beams in a beam stop of appropriate material.
4. Use diffusely reflecting materials near the beam, where appropriate.
5. Personnel within the laser-controlled area must be provided with appropriate laser protective eyewear.
6. Secure and locate the laser such that the beam path is above or below eye level in any standing or seated position.
7. Have all windows, doorways, open portals, etc. from an indoor facility covered or restricted so-as-to reduce transmitted beams below appropriated ocular MPE levels.
8. Require storage or disabling of lasers when not in use.

More specific requirements for the safe usage of Class IIIB and Class IV lasers are described in Section 12.0 Safety Procedures.

11.1 Entryway Control Measures

In addition to the above requirements, there are specific controls required at the entryway to a Class IV laser controlled area. These can be summarized as follows:

1. All personnel entering a Class IV area while the laser is enabled shall be adequately trained and provided proper laser protective eyewear.
2. All personnel shall follow applicable administrative and procedural controls.
3. All Class IV area/entryway controls shall allow both rapid entrance and exit under all conditions.
4. The controlled area shall have a clearly marked "Panic Button" (disconnect switch) that allows rapid deactivation of the laser.

In addition, Class IV areas also require some form of area-entryway controls. Three options are provided that will meet the requirements of this program. Depending on the surrounding structures, environment, and the ever-changing needs of laser science researchers, different combinations of these controls may be required to obtain a practical strategy for safe operation. Therefore, any combination of these strategies will suffice. These options include:

a. Non-Defeatable Entryway Controls:

A non-defeatable control, such as a magnetic switch built into the entryway door which actuates a "beam off" condition when the door is opened is one option. In this case, training is required only for persons regularly working in the laser area.

b. Defeatable Entryway Controls:

Defeatable controls may be used at an entryway, for example, during long-term testing in a laser area. In this case, the controls may be temporarily bypassed if it is clearly evident that there is no hazard at the point of entry. Training is required for all personnel who frequently require area entry.

c. Procedural Entryway Controls:

A blocking barrier, screen, or curtain which can block or filter the laser beam at the entryway may be used inside the controlled area to prevent the laser light from exiting the area at levels above the applicable MPE level. In this case, a warning light or sound is required outside the entryway that operates when the laser is energized and operating. All personnel who work in the facility shall be appropriately trained.

12.0 Safety Procedures - General Precautions

The OEHS shall be notified of the purchase and/or installation of any laser, regardless of the laser class. Such notification must include the classification, media, output power or pulse energy, wavelength, repetition rate (if applicable), special attachments (frequency doublers, etc.), beam size at the laser aperture, beam divergence and the names of all users. Eye protection shall be verified or purchased at the time of laser purchase.

No attempt shall be made to place any shiny or glossy object into the laser beam other than that for which the equipment is specifically designed.

Eye protection devices that are designed for protection against radiation from a specific laser system shall be used when engineering controls are inadequate to eliminate the possibility of potentially hazardous eye exposure. This generally applies only to Class IIIB and Class IV lasers. All laser protective eyewear shall be clearly labeled with optical density values and wavelengths for which protection is affected.

Skin protection can best be achieved through engineering controls, and if the potential exists for damaging skin exposure, particularly for ultraviolet lasers (200-400 nm), then skin covers and/or "sun screen" creams are required.

Hands - Most gloves will provide some protection against laser radiation. Tightly woven fabrics and opaque gloves provide the best protection.

Arms - A laboratory jacket or coat can provide protection for the arms. For Class IV lasers, consideration should be given to flame resistant materials.

1. Class I, Class II and Class IIIA Lasers:

Accident data on laser usage has shown that Class I, Class II, Class IIA and Class IIIA lasers are normally not considered hazardous from a radiation standpoint unless illogically used. However, direct exposure on the eye by a beam of laser light should always be avoided with any laser, regardless of how low the power.

2. Class IIIB Lasers:

Laser beams shall be contained whenever possible. When uncontained beams are used, the following precautions shall be taken:

- Minimally, a Class IIIB warning sign shall be placed at all entrances to the area when the laser beam is operating and access to the area must be authorized by the person(s) responsible for the area. Ideally, a laser activation warning light assembly shall be installed outside the entrance to each laser room facility containing any Class IIIB laser or laser systems. A notice outside the area shall indicate the meaning of the blinking light.
- The laser beam shall be terminated at the limit of its useful distance. A dull black (highly absorbing/low reflectance) surface is recommended for visible frequency lasers and beam traps or terminators with total absorbers appropriate to the wavelength for UV or IR lasers.
- Specularly reflecting surfaces in or near the beam path shall be minimized.
- The area shall be well lighted to constrict pupils.
- A Laser Safety Plan (template in Appendix C) is required for all Class IIIB lasers and must include emergency procedures.
- The laser shall be positioned and the beam contained such that the beam does not exit the immediate area of use.

3. Class IV Lasers:

All requirements as for Class IIIB lasers shall be followed as well as, the following safeguards:

- A total hazard assessment shall be conducted before a high power laser is used. This shall include evaluation of Nominal Hazard Zones (NHZ), measurements (if deemed necessary) and other such analytical techniques.
- Devices shall be located in an area designated specifically for laser operations (laser controlled area). Access during operation requires authorization of the person responsible for the area. In conditions where the beam path is not completely enclosed, access shall be limited to properly trained and knowledgeable personnel.

- An entryway control shall be used as described in Section 10.1. Such measures shall permit rapid egress by the personnel at all times and admittance to the area under emergency conditions.
- A control-disconnect switch or equivalent device shall be available near the exit for deactivating the laser.
- A laser activation warning light assembly shall be installed outside the entrance to each laser room facility containing a Class IV laser or laser system. A notice outside the area shall indicate the meaning of the blinking light (if such light is used as a means of access control).
- Care must be taken to insure that the hands, arms, or other parts of the body do not intersect the beam.
- The system must have provisions for quickly disengaging the laser power source from the electrical main during emergency.
- A highly absorbent beam trap of fire resistant material shall terminate the beam.
- For infrared lasers, since the radiation is invisible, areas that are exposed to reflections of the beam shall be protected by fully enclosing the beam and target area.
- Ultraviolet laser beam radiation shall require a beam shield that a countdown procedure must be in place to signify the firing of single pulse laser types (e.g. Q-switch) to ensure all present are aware of the time of the operation.
- The use of laser protective eyewear is mandatory with Class IV lasers. Protective eyewear shall be fabricated of plastic or glass absorption filters appropriate for the laser. All laser protective eyewear shall be clearly labeled with the optical density values and wavelengths for which protection is afforded. If eyewear provides insufficient protection due to affecting the ability to perform tasks while wearing the eyewear, all involved personnel must be familiar with the laser properties and the current states of laser radiation in the experimental area and receive extensive training as to proper conduct around the laser. Maximum feasible eye protection must still be worn at all times.

13.0 Optical Fiber (Lightwave) Communication Systems

Under normal operation such systems are completely enclosed (Class 1) with the optical fiber and optical connectors forming the enclosure. Under installation or service conditions, or when an accidental break in the cable occurs, the system can no longer be considered enclosed. If engineering controls limit the accessible emission to levels below the applicable MPE, no controls are necessary. If the accessible emission is above the MPE, the following requirements shall apply:

- Only authorized and trained personnel shall be permitted to perform service on lightwave transmission systems if access to laser emission is required.
- Only authorized and trained personnel shall be permitted to use the laser test equipment (Optical Loss Test Set, Optical Time Domain Reflectometer, etc.) during installation and/or service.

- All unauthorized personnel shall be excluded from the service and installation area when there is a possibility that the system may become energized. The immediate area shall be considered a temporary laser controlled area.
- Staring into the end of any broken, severed or unterminated optical fiber or cable shall be avoided.
- The end of any broken, severed or unterminated optical fiber shall not be viewed with unfiltered optical instruments (microscopes, telescopes, etc.). An exception to this is the use of indirect image converters such as an infrared image converter or closed circuit television system for verification that a fiber is not energized.
- During a splicing operation (either installation or service) if it is required that the ends of the fiber be examined with an eye-loupe for a satisfactory cut, only an eye-loupe containing an appropriate filter shall be used. If a fusion splicer is used, rigid adherence to the appropriate operating safety procedures shall be enforced.

14.0 Training Requirements

The area supervisor will be responsible for training all personnel in their area appropriate to the class of laser in use. The LSO shall insure that all employees assigned to service, maintain, install, adjust, and operate laser equipment be appropriately trained and qualified by appropriate review of training documentation. The training program shall be designed appropriate to the class of laser radiation accessible during the required task(s) of the personnel. Laser area supervisors shall maintain the name of all persons trained and date of training and inform the OEHS of training completions and requirements.

A. Class I Training:

Class I training can be limited, in general, to information contained and provided in the operation/maintenance manuals of the laser Manufacturer.

No additional operator training is necessary provided the Class I status is maintained.

B. Class II, Class IIA and Class IIIA Training:

Training for these classes of lasers shall include information contained in the operation/maintenance manuals of the laser manufacturer and, where appropriate, additional basic safety guide literature of a general topic nature. Short, concise audio-visual programs can also enhance understanding of hazards in some use scenarios especially where these laser systems are subject to frequent operator changes. A copy of the UAH Laser Safety Manual shall be supplied to all personnel requiring training.

C. Class IIIB and Class IV Training:

Class IIIB and Class IV training is required for all personnel working with these classes of lasers, including operators, maintenance personnel, service persons as-well-as those on the technical support staff, technicians, etc. The training shall provide a complete understanding of the requirements of a safe laser environment and include discussion of the hazards, safety devices required, procedures related to operating the equipment, warning sign requirements and description of medical surveillance practices. Emphasis should be placed on practical, safe laser techniques and procedures as well as safety devices that provide an overall safe environment.

APPENDIX A

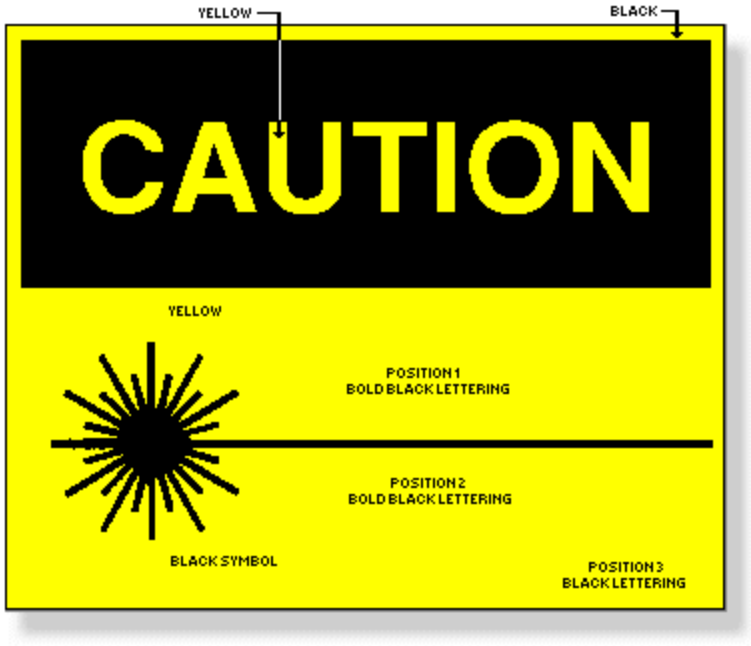
MAXIMUM PERMISSIBLE EXPOSURE LIMITS

Laser type	Wave-length (µm)	MPE level (W/cm^2) 0.25 sec	10 sec	600 sec	30,000 sec
CO2 (CW)	10.6	---	100.0×10^{-3}	---	100.0×10^{-3}
Nd: YAG (CW)	1.33	---	5.1×10^{-3}	---	1.6×10^{-3}
Nd: YAG (CW)	1.064	---	5.1×10^{-3}	---	1.6×10^{-3}
Nd: YAG (Q-switched)	1.064	---	17.0×10^{-6}	---	2.3×10^{-6}
GaAs (Diode/CW)	0.840	---	1.9×10^{-3}	---	610.0×10^{-6}
HeNe (CW)	0.633	2.5×10^{-3}	---	293.0×10^{-6}	17.6×10^{-6}
Krypton (CW)	0.647 0.568 0.530	2.5×10^{-3} 31.0×10^{-6} 16.7×10^{-6}	--- --- ---	364.0×10^{-6} 2.5×10^{-3} 2.5×10^{-3}	28.5×10^{-6} 18.6×10^{-6} 1.0×10^{-6}
Argon (CW)	0.514	2.5×10^{-3}	---	16.7×10^{-6}	1.0×10^{-6}
XeFl (Excimer/ CW)	0.351	---	---	---	33.3×10^{-6}
XeCl (Excimer/ CW)	0.308	---	---	---	1.3×10^{-6}

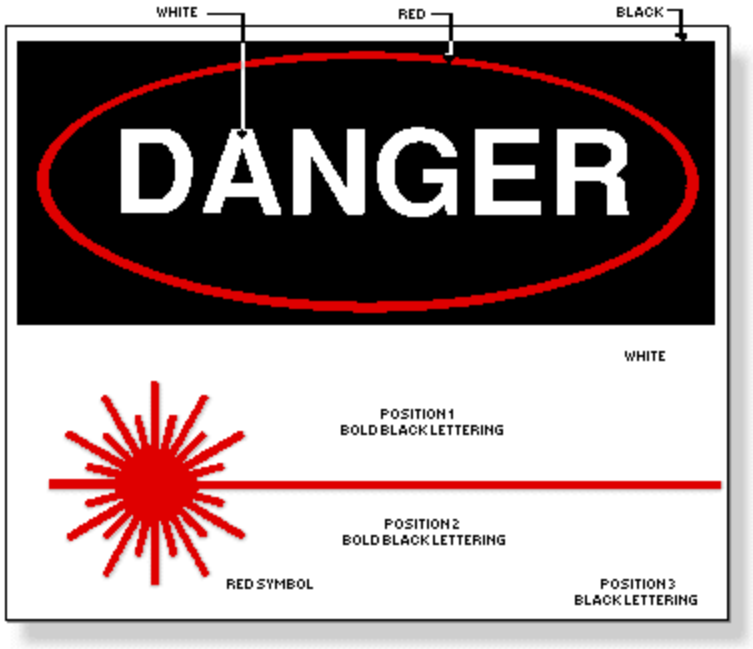
APPENDIX B

LASER WARNING SIGNS

CAUTION



DANGER



APPENDIX C

LASER SAFETY PLAN TEMPLATE

THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

LASER SAFETY PLAN TEMPLATE

This form must be accompanied by a site-specific Laser Safety Plan for the equipment described below. Refer to the UAH Laser Safety Manual for more specific requirements and guidelines.

Laser Safety Plan Development for: (please circle)

1. **Laser or laser system to be acquired**
2. **Current on-site laser or laser system**

General description/specifications:

_____

_____

_____

_____

Vendor or Loaner:

_____

_____

_____

Laser Classification:

_____

_____

_____

Please provide the names and signatures of the Faculty members, PI, and department head/chair acquiring the laser or laser system (through purchase or loan).

Faculty Member
Or PI: _____ _____

Printed or Typed Name Signature

Department Head/
Chair: _____ _____

Printed or Typed Name Signature

_____ _____

Faculty/PI Department & Campus Address Campus Phone No.

1. Provide technical specifications of the laser or laser system and a brief description of the work to be performed with the laser (include a copy of the vendor's specifications and classification if available).

   - Wavelength range: _____
   - Emission Duration: _____
   - Maximum Power or Energy: _____

_____

_____

2. Describe the facility/environment in which the laser or laser system will be used (research laboratory, teaching laboratory, office, etc.). Include building room/laboratory number, floor plan and laser location (of known). Attach additional information as necessary.

_____

_____

_____

3. Describe the level of laser safety knowledge and training of the personnel working with the laser. Also address the presence of any other personnel who may not work directly with the laser, but may be exposed to the hazards in the laser work area.

_____

_____

_____

4. Describe the safety and control measures already present at the location (if any).

_____

_____

_____

5. Describe the safety and control measures that will be implemented along with the laser installation and how those measures will be achieved, including any protective housing, laser signs, etc.

_____

_____

_____

_____

6. Describe any special ancillary hazards such as toxic materials/fumes, electrical exposures, or compressed gases and specific control measures that will be implemented to control such hazards.

_____

_____

_____

7. Will operation of this laser or laser system involve the presence of any exposure to the general public at any time (such as special tours) or any other unusual circumstances? If yes, please describe.

8. Will operation of this laser or laser system involve using lasers for health care, medical, or surgical applications to animals or human patients? If yes, please describe procedures in which the laser will be used.

OEHS USE ONLY

To Be Completed by the Laser Safety Officer

Plan No.:_____

OEHS Action:

- **Approved**
- **Approved with Provisions (see comments)**
- **Deferred for Revision (see comments)**
- **Disapproved**

Comments:

OEHS Director or LSO: _____ _____

Signature **Date**