# UAH

## The University of Alabama in Huntsville

# LASER SAFETY MANUAL

2021 Rev.3

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# 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 five 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 or their assigned representative(s) must conduct the review. The review dates are documented below.

| Review Date | Revision Number | Reviewing Party Printed/Typed Name/Title | Reviewing Party Signature |
|---|---|---|---|
| 1999 | Original Plan | Randy Wright/Director- OEHS | |
| | | Dr. John Dimmoick/Director-CAO | |
| 07/2002 | 1 | Marcia Green/Director- OEHS | |
| 07/2002 | 1 | Dr. John Dimmoick/Director-CAO | |
| 08/2014 | 2 | Marcia Pendleton/Director- OEHS | |
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# DISCLAMIER

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 Z136.1-2014). 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 lasers.

Each University unit operating lasers or laser systems will provide documentation, in the form of a site-specific Laser Safety Plan and/or 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 Z136.1 and accepted as general industry guidelines to ensure 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 a Laser Safety Plan and/or 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 the Radiation Safety Committee.
- Attending laser safety training.
- Registering for the medical surveillance program if working with Class 3B or Class 4 lasers. Contact the Office of Environmental Health and Safety for a referral to our current Occupational Health provider if you plan to work with Class 3B or Class 4 lasers.
- Notifying OEHS or the Laser Safety Officer immediately in the event of an exposure to a Class 3B or Class 4 laser beam or reflection.
- Participating in accident investigations involving lasers.

## B. Laser Operators are responsible for:

- Following laboratory the site-specific Laser Safety Plan and/or 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 including, but not limited to:
  - Initiating or completing a hazard evaluation
  - Confirming the classification of lasers
  - Assuring proper control measures are in place or approving substitute controls
  - Approving the site-specific Laser Safety Plan and/or standard operating procedures
  - Recommending and/or approving eyewear and other protective equipment
  - Assuring appropriate signs and labels are used
  - Approving laser facility controls
- Providing assistance in evaluating and controlling hazards.
- Reviewing the Laser Safety Manual as required.
- Maintenance of laser safety audit and use records.
- Conducting or arranging laser safety training for all personnel working with lasers.
- Participating 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, the 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 the following 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) for each laser as established in ANSI Z136.1-2014.

## Class 1

A Class I laser is considered to be incapable of producing hazardous radiation exposure levels during operation and is typically exempt from any control measures.

## Class 1M

A Class 1M laser system is considered to be incapable of producing hazardous exposure conditions during normal operation unless the beam is viewed using a collecting optical system such as a telescope. Class 1M systems are typically exempt from any control measures unless the beam is being viewed with optic aids.

## Class 2

A Class 2 laser system emits light in the visible portion of the spectrum (400 nm to 700 nm). The aversion response of the eye (~0.25 seconds) is typically all that is required for eye protection.

## Class 2M

The Class 2M laser system is similar to the Class 2; however, the Class 2M system may produce hazardous exposure conditions if the beam is observed using optical aids, such as a telescope.

## Class 3R

The Class 3R laser system is potentially hazardous under some specular and direct reflection view conditions if the eye is focused and stable; however, the probability of an

actual injury is small. The Class 3R laser system does not pose a fire or diffuse reflection hazard. Class 3R laser systems have an accessible output of 1-5 mW for continuous wave systems.

## Class 3B

Medium-powered lasers fall under the Class 3B category of lasers. Class 3B laser systems may be hazardous under direct or specular reflection, but the Class 3B laser system does not normally pose a fire hazard, a diffuse reflection hazard, or a laser generated air contaminant production hazard. Class 3B lasers and laser systems have an accessible output of 5 – 500 mW. Engineering controls are typically required for Class 3B lasers.

## Class 4

High-powered lasers that present potential acute hazard to the eye and skin are categorized as Class 4 lasers. Class 4 lasers pose a fire hazard and may produce laser-generated air contaminants and hazardous plasma radiation. Class 4 lasers have an accessible output of greater than 500 mW for continuous wave systems. Engineering controls are required for all Class 4 lasers.

The following table is a summary of requirements for the specific laser class (taken from ANSI Z136.1-2014 Table 1-1)

**ANSI Z136.1-2014 Table 1-1. Requirements by Laser Class**

| Class | Control Measures | Training | LSO | Engineering Controls |
|---|---|---|---|---|
| 1 | Not Required | Not Required | Not Required | Not Required |
| 1M | Required | Application Dependent | Application Dependent | Application Dependent |
| 2 | Not Required | Not Required | Not Required | Not Required |
| 2M | Required | Application Dependent | Application Dependent | Application Dependent |
| 3R | Not Required | Not Required | Not Required | Not Required |
| 3B | Required | Required | Required | Required |
| 4 | Required | Required | Required | Required |

**Reclassification of Class 1 Lasers**

Any laser or laser system can be classified as a Class 1 laser if the following controls properly enclose the laser to prevent contact with the laser radiation:

- Protective Housing
  - The laser system must be housed in a protective enclosure to prevent the escape of laser radiation.
  - Personnel contact with the laser must be prohibited.

    - Maintenance or service tasks must be performed with the control measures established for the higher laser class.
- Safety Interlocks
    - Safety interlocks must be installed whenever the laser can be opened, removed or displaced.
    - Service adjustments or maintenance work shall not render the interlocks inoperative. If the work to be performed requires the interlocks to be defeated, the service/mainteanance work shall be performed in accordance with the requirements of the higher laser class.
- Warning Signs and Labels
    - The enclosure shall be labeled with the "Caution-Enclosed Laser" sign.
    - The label must be placed directly to the laser to display the laser classification in the absence of the enclosure.

# 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 Hazards

The human body is vulnerable to the output of certain lasers, and under certain circumstances, exposure can result in damage to the eye. 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:

- Radiation at the visible and near-infrared wavelengths is absorbed and can have hazardous effects on the retina.
- Radiation at the near ultraviolet and middle infrared wavelengths is 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 400 nm (violet light) to 1400 nm (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.

### 5.2 Skin Hazards

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 high level of danger and must be guarded against.

## 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 high-powered lasers. The potential for electrical hazards most commonly results from inappropriate electrical installations, 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 applicable to the potential hazard when developing a Laser Safety Plan for each 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 the adequacy and/or necessity of control measures. As a minimum, the following must be considered when performing a hazard evaluation:

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 the beam path(s)
5. Permanence of the 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 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 useed 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 ANSI Z136.1 standard.

## 8.1 Engineering Safety and Control Measures

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

- protective housing
- 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:

- Laser Safety Plan
- Other applicable Standard Operating Procedures (e.g. maintenance, alignment, other safety procedures, etc.)
- Laser hazard and safety training for faculty, staff and students
- Authorized personnel requirements
- Required alignment procedures
- Required eye and skin protection
- Protective measures for service personnel
- Protective measures for visitors and spectators
- Notification of the presence/usage of any hazardous materials and their proper handling and disposal

- Site-Specific Laser Safety Plan including (but not limited to):
    - Laser hazard and safety training for faculty, staff and students
    - Authorized personnel requirements
    - Required alignment procedures
    - Required eye and skin protection
    - Protective measures for service personnel
    - Protective measures for visitors and spectators
    - Notification of the presence/usage of any hazardous materials and their proper handling and disposal
- Other applicable Standard Operating Procedures (e.g. maintenance, alignment, other safety and usage procedures)

A sample site-specfic Laser Safety Plan template is provided in Appendix C.

A summary of controls for each individual laser class taken from Z136.1-2014 Tables 10.1 and 10.2 is given in Appendix A.

## 9.0 Specific Engineering Contols

There are some uses of Class 3B and 4 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 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 1 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. As a result, 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 1 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. A computer controlled positioning table may be located within the area. These systems do not meet the stringent "human access" requirements for a Class 1 laser, but the real hazards are well confined.

This 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 based on the class of embedded laser.

Personal 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 shall be established in a manner similar to that of any embedded Class 4 laser.

### 9.3 Totally Unenclosed Beam Path:

Applications where high power (Class 3B and Class 4) lasers are used in an unenclosed beam conition 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 Areas

When the entire beam path from a Class 3B or Class 4 laser is not sufficiently enclosed and/or baffled such that access to radiation above the Z136.1 Maximum Permissible Exposure (MPE), a

"Laser Controlled Area" is required. The laser controlled area shall be defined in the Site-Specific Laser Safety Plan and/or SOP. During periods of usage, a controlled area may be established on a temporary basis. The controlled area will encompass the entire hazard zone. The controls required for both Class 3B and Class 4 lasers are as follows:

### 10.1 Class 3B Controlled Areas

Class 3B lasers with an open beam configuration may be operated only in designated laser controlled areas. All personnel who enter into a Class 3B laser controlled area must be properly trained. In addition, the following controls are required for Class 3B areas:

- The area must be posted with the appropriate warning signs indicating the nature of the hazard. Signage must conform with ANSI Z136.1 guidelines. These signs must be posted at all entrances to the laser controlled area. Examples of the required signage are provided in Appendix B of this procedure.
- Only authorized personnel may operate the laser.
- Beam stops must be installed to terminate the laser beam at the end of its useful path.
- Lasers should not be mounted at eye level.
- Laser protective eyewear must be worn in areas where the laser exposure could exceed the MPE.

### 10.2 Class 4 Controlled Areas:

An area designated as a Class 4 laser controlled area must meet the requirements of a Class 3B laser designated area in addition to the following controls measures:

- Provisions for emergency egress from a laser controlled area shall be made. Any interlocks present shall not interfere with the emergency egress. In addition, control measures shall not interfere with the ability of emergency response personnel to enter the area.
- Visible warning signs or alarms must be placed at the entrance of the controlled area to indicate that the laser is in operation.
- Class 4 lasers must have a master key or code which is available only to authorized personnel.
- Each Class 4 laser must have an emergency deactivation switch.
- Entry to rooms containing Class 4 lasers must be interlocked with the laser to prevent unexpected entry. Locking entryway doors is not acceptable since it prevents entry by emergency responders.

## 11.0 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.

Personal protective equipment must be utilitzed in accordance with Section 12.0 of this procedure.

## 1. Class 1, Class 1M, Class 2, Class 2M and Class 3R

Accident data on laser usage has shown that Class 1, Class 2M, Class 2, Class 2M and Class 3R lasers are not normally considered hazardous from a radiation standpoint unless improperly 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 3B Lasers:

Class 3B laser beams shall be contained whenever possible. When uncontained beams are used, the following precautions shall be taken.

- Minimally, a Class 3B 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 3B 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-lit to constrict the pupils of the eyes of the occupants in the area.
- A Laser Safety Plan is required for all Class 3B lasers and must include emergency procedures. A template to be used as a guide in the development of the Laser Safety Plan is provided in Appendix C.
- The laser shall be positioned and the beam contained such that the beam does not exit the immediate area of use.

## 3. Class 4 Lasers:

All requirements for Class 3B lasers shall be followed in addition to 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 10.2. Such measures shall permit rapid egress by the personnel at all times and admittance to the area by emergency responders.
- 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 4 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 ensure 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 stop of fire-resistant material shall terminate the beam.
- Since infrared laser 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.

## 12.0 Personal Protective Equipment

*Protective Eyeware*

- Whenever possible, engineering controls should be the first line of defense when minimizing laser hazards; however eye protection should be worn as a means to prevent eye injury.

- Laser protective eyewear which conforms with the specifications of Z136.1-2014 must be worn whenever working with Class 3B or 4 lasers. The laser protective eyewear being used must be appropriate for the type of laser being used.
- Protective eyewear devices shall meet the following requirements:
    - Fit around the entire area of the eye
    - Provide adequate visibility
    - Be maintained in proper condition and provide the required optical density (OD) or greater at the appropriate wavelengths
    - All protective eyewear must be clearly labeled with the OD and the correct wavelength of protection.
- Eyewear must be properly maintained and remain in good condition. Eyewear shall be stored in a clean and sanitary condition away from dust and debris. Eyewear shall be stored in a manner that does not scratch the lens.
- Users shall inspect eyewear for signs of deterioration or damage on a periodic basis.

*Skin Protection*

- Where there is a possibility of exposure to laser radiation greater than the MPE for skin, individual users are required to use protective gloves, clothing, and/or shields.
- Skin protection must be stored and maintained in a clean and sanitary condition. The skin protective equipment shall be inspected on a regular basis for indications of damage or deterioration.

### *Other Personal Protective Equipment*

- In the event laser-generated air contaminants exceed the appropriate exposure limit, respiratory protection may be required. All use of respiratory protection must be performed in accordance with University procedures.

## 13.0 Optical Fiber (Lightwave) Communication Systems

Under normal operation Optical Fiber Communication 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 light wave 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 spicing 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 ensure 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 to be 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 1 Training:**

Class 1 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 1 status is maintained.

**B. Class 1M, Class 2, Class 2M and Class 3R 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 3B and Class 4 Training:**

Class 3B and Class 4 training is required for all personnel working with these classes of lasers, including operator, 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

## CONTROL MEASURES FOR THE INDIVIDUAL LASER CLASSES-- ENGINEERING CONTROLS (Taken from ANSI Z136.1-2014 Table 10a.)

| Engineering Control Measures | Classification | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 1M | 2 | 2M | 3R | 3B | 4 |
| Protective Housing (4.3.1) | X | X | X | X | X | X | X |
| Without Protective Housing (4.3.1.1) | LSO shall establish Alternative Controls | | | | | | |
| Interlocks on Removable Protective Housings (4.3.2) | ∇ | ∇ | ∇ | ∇ | ∇ | X | X |
| Service Access Panel (4.3.3) | ∇ | ∇ | ∇ | ∇ | ∇ | X | X |
| Key Control (4.3.4) | — | — | — | — | — | • | X |
| Viewing Windows, Display Screens and Collecting Optics(4.3.5.1) | Assure viewing limited < MPE | | | | | | |
| Collecting Optics (4.3.5.2) | | | | | | | |
| Fully 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 |
| 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 |
| Outdoor Control Measures (4.3.11) | X | * NHZ | X NHZ | * NHZ | X NHZ | X NHZ | X NHZ |
| Laser in Navigable Airspace (4.3.11.2) | X | * NHZ | X NHZ | * NHZ | X NHZ | X NHZ | X NHZ |
| Temporary Laser Controlled Area (4.3.12) | ∇ MPE | ∇ MPE | ∇ MPE | ∇ MPE | ∇ MPE | — | — |
| Controlled Operation (4.3.13) | — | — | — | — | — | — | • |
| Equipment Labels (4.3.14 and 4.7) | X | X | X | X | X | X | X |
| Laser Area Warning Signs and Activation Warnings (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 |
| * | May apply with use of optical aids |

## CONTROL MEASURES FOR THE INDIVIDUAL LASER CLASSES-- ADMINISTRATIVE AND PROCEDURAL CONTROLS (Taken from ANSI Z136.1-2014 Table 10b.)

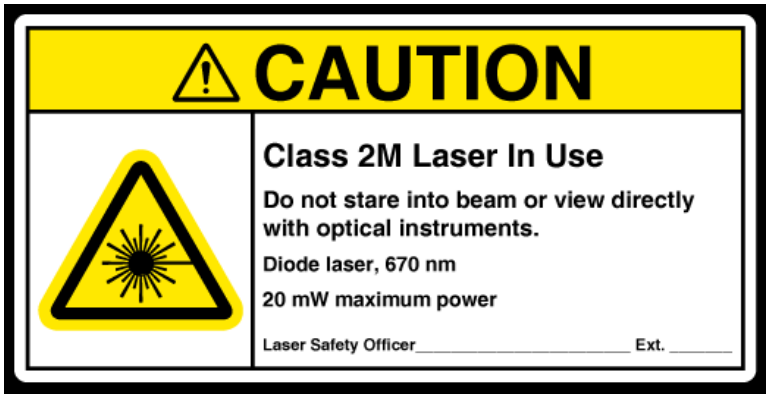
| Administrative and Procedural Control Measures | Classification | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 1M | 2 | 2M | 3R | 3B | 4 |
| Standard Operating Procedures (4.4.1) | — | — | — | — | — | • | X |
| Output Emission Limitations (4.4.2) | — | — | — | — | LSO Determination | | |
| Education and Training (4.4.3) | — | • | • | • | • | X | X |
| Authorized Personnel (4.4.4) | — | * | — | * | — | X | X |
| Alignment Procedures (4.4.5) | ∇ | ∇ | ∇ | ∇ | ∇ | X | X |
| Protective Equipment (4.6) | — | * | — | * | — | • | X |
| Spectators (4.4.6) | — | * | — | * | — | • | X |
| Service Personnel (4.4.7) | ∇ | ∇ | ∇ | ∇ | ∇ | X | X |
| Demonstration with General Public (4.5.1) | — | * | X | * | X | X | X |
| Laser Optical Fiber Transmission Systems (4.5.2) | MPE | MPE | MPE | MPE | MPE | X | X |
| Laser Robotic Installations (4.5.3) | — | — | — | — | — | X NHZ | X NHZ |
| Protective Eyewear (4.6.2) | — | — | — | — | — | • | X |
| Window Protection (4.6.3) | — | — | — | — | — | X | X NHZ |
| Protective Barriers and Curtains (4.6.4) | — | — | — | — | — | • | • |
| Skin Protection (4.6.6) | — | — | — | — | — | X | X NHZ |
| Other Protective Equipment (4.6.7) | Use may be required | | | | | | |
| Warning Signs and Labels (4.7) (Design Requirements) | — | — | • | • | • | X NHZ | X NHZ |
| Service Personnel (4.4.7) | LSO Determination | | | | | | |
| Laser System Modifications (4.1.2) | LSO Determination | | | | | | |

LEGEND:

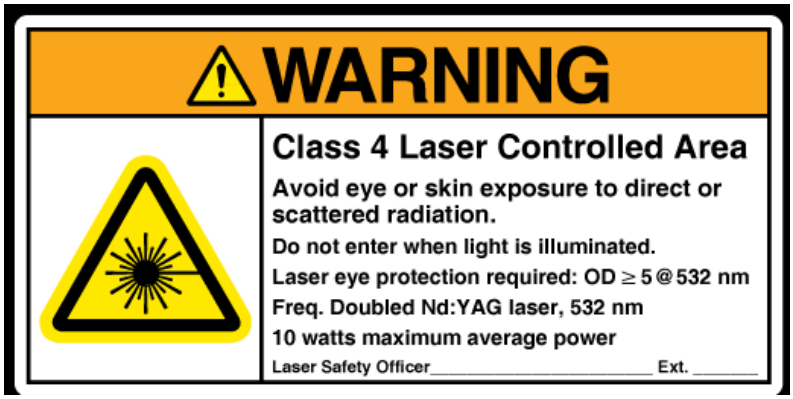
| | |
|---|---|
| X | Shall |
| • | Should |
| — | No requirement |
| ∇ | Shall if enclosed Class 3B or Class 4 |
| MPE | Shall if MPE is exceeded |
| NHZ | Nominal Hazard Zone analysis required |
| * | May apply with use of optical aids |

# APPENDIX B: LASER WARNING SIGNS

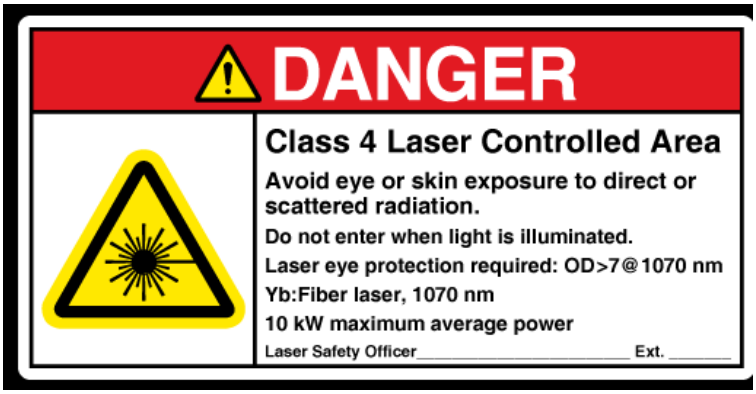
An area which contains a Class 2 or 2M laser shall be posted with the appropriate yellow "Caution" sign.




An area which contains a Class 3R, 3B or 4 laser shall be posted with an appropriate orange "Warning" sign. "Warning" should be used on all Class 3B and 4 lasers where exposure "*could* result in death or serious injury".




An area which contains a Class 4 (multi-kilowatt) laser shall be posted with the red "Danger" sign. "Danger" should be used where the exposure "*will* result in death or serious injury".



# 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, lasers 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**