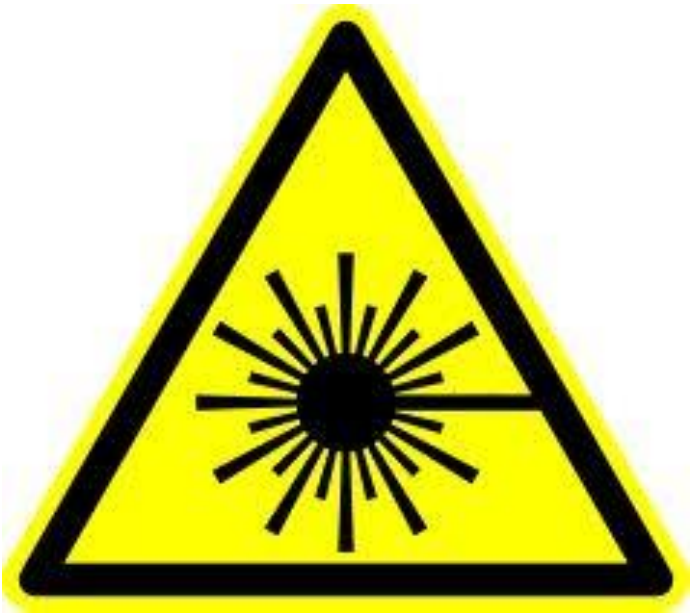
# Laser Safety Manual

# for

# Bowling Green State University



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# LASER SAFETY MANUAL

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**GUIDELINES FOR LASER SAFETY**

Bowling Green State University
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## 1. Rationale and Purpose

Since their invention just a few decades ago, lasers have quickly become commonplace in modern society, finding uses in fields as diverse as communications, electronics, construction, manufacturing, medicine, printing and many other fields. Most people are familiar with laser scanners used at the checkout stations of their local store or with laser printers associated with personal computer equipment. In spite of their widespread use and familiarity, some lasers nonetheless are capable of causing personal injury and must be used with caution. Lasers with high output power or with radiation in particular wavelength ranges can cause serious eye or skin injury. Eye injuries can occur by direct viewing of the beam of such lasers or even from specular reflection of those laser beams. Higher powered lasers can burn exposed skin, ignite flammable materials, and activate chemicals that can release hazardous fumes, gases, or debris into the environment. Electrical equipment and associated optical apparatus required to produce the lasing action and/or to control the laser beam also can cause electrical shock and fire hazards. For these reasons lasers must be used with caution, and persons in charge of their applications and use, especially in research environments, have a responsibility to protect not only themselves but also others who may come in contact with such devices.

The purpose of this document is to set forth the policies of Bowling Green State University with respect to the operation and use of lasers or laser systems, and to describe the procedures to be followed for the safe operation and use of such devices. These policies apply to lasers of Class 2 or higher (as described in Sec. 2) that are used for any purpose, whether for instruction, demonstration, entertainment, administration, processing, medical procedures, or research. The policies apply to individuals who use lasers on this campus or in any facility operated by or under the auspices of BGSU. They also apply to persons from off campus who may be involved with the installation, calibration, repair, maintenance, or temporary use of such devices at BGSU or at an affiliated facility.

The intent of the BGSU Laser Safety Program is to:

- Provide reasonable and adequate guidance for the safe operation of lasers by evaluating and minimizing hazards associated with their use
- Identify the responsibility of various individuals involved with the use of lasers
- Specify the instruction and/or training required of individuals who operate specific lasers and laser systems
- Outline relevant safety procedures to be employed with certain lasers and laser systems
- Recommend equipment and safeguards necessary for safe use of lasers, laser systems, and the facilities or spaces where they are used.

These guidelines were developed in accordance with standards of the American National Standards Institute, Inc. (ANSI), as revised and approved December 10, 2014, and the essential principles of those standards are incorporated by reference.

## 2. Laser Hazard Classification

Lasers are divided by ANSI into four main classes according to the relative hazards associated with their use. These classifications are as follows:

Class 1: Low power lasers or laser systems that are incapable of causing injury, even if the beam is viewed directly. Such lasers or laser systems do not require special precautions and are exempt from specifics of these guidelines. Class 1 lasers include laser pointers, laser copiers, laser scanners, and other similar equipment.

Class 1M: Low power lasers incapable of causing injury except when viewed with optical aids such as an eye loupe or telescope. These lasers are exempt from any controls other than measures to prevent optically aided viewing.

Class 2: Low power visible lasers producing output not exceeding 1 milliwatt. Injury can occur from extended direct viewing of the beams of such lasers, but protection normally is afforded by the natural aversion response of the eye (blinking). Procedural controls are not required for such lasers except for applications where intentional intrabeam exposure is intended.

Class 2M: Low power visible lasers with output not exceeding 1 milliwatt. Protection is afforded by natural aversion response, but such lasers may be hazardous if the beam is viewed with optical aids. Procedural controls are necessary to prevent optically aided viewing.

Class 3R: Lasers that produce visible or invisible radiation with an output power between 1 and 5 milliwatts. May be hazardous under certain direct and specular viewing conditions if the eye is focused and stable, but the probability for injury is small under normal operating conditions. Such lasers do not pose a diffuse reflection or fire hazard. Procedural controls not required except to prevent intrabeam exposure.

Class 3B: Lasers that produce visible or invisible radiation with an output power from 5 to 500 milliwatts. Such lasers are considered medium power and are capable of producing eye injury when viewed even momentarily with the unaided eye. Class 3B lasers usually do not produce a hazardous diffuse reflection or fire hazard, but skin burns are possible at the upper end of this power range. Procedural and administrative controls are required for such lasers as well as operator training. Medical eye surveillance is also recommended for persons working regularly with such lasers.

Class 4: Lasers emitting either visible or invisible radiation with power greater than 0.5 Watts. Such lasers are capable of causing injury to the eye or skin even from momentary viewing of the direct beam or from specular or diffuse reflection. Class 4 lasers also can produce fire hazard.

Class 1 lasers generally are considered non-hazardous and do not require special precautions in their use. Such lasers fall outside the purview of these guidelines.

Class 1M lasers are non-hazardous except when the beam is viewed with optical aids. Such lasers are exempt from control measures other than those to prevent optically aided viewing.

Class 2 lasers also are non-hazardous under normal operating conditions, but injury can be sustained with improper use. For instance, forced or intentional long term direct viewing of the laser beam for a Class 2 laser can result in eye injury. Operators of these systems need instruction in proper use and handling, but no special precautions are needed for the rooms where such lasers are used.

Class 2M lasers are generally safe, but can cause injury if collecting optics are used. For these reasons, special instruction in the care and handling of such instruments is needed as well as security to insure that items such as binoculars or microscopes are not able to be used accidentally with such lasers.

Class 3R lasers are potentially hazardous under certain viewing conditions, but the probability of injury is small under normal operation. Procedural controls are not required for such lasers except those to prevent intrabeam viewing.

Class 3B lasers are capable of producing injury if viewed directly, and injuries also are possible by specular reflection. But these lasers usually do not produce hazardous diffuse reflections or fire hazards. Special eyewear may be needed for operators of such lasers and particular attention should be given to the environment where such lasers are operated. For example, partitions or beam stops may need to be installed, and items that could cause specular reflection removed.

Class 4 lasers are capable of causing injury to the eye or skin and can produce dangerous specular and diffuse reflections. They also can produce fire hazards. Such lasers clearly require the most serious attention to safety precautions.

Safety procedures depend not only on the class of laser but also on the use to which the laser is put. For example, a Class 3B open beam laser that emits invisible radiation and that is used in an unsupervised research or instructional environment by different individuals who may have received no or only minimal training, can be more dangerous than a Class 4 laser with a visible beam that is contained within an enclosure and used, say, for routine processing work in the hands of a single experienced operator. Accordingly, the levels of control vary with the situation and each case must be examined separately. The Laser Safety Officer will work in conjunction with laboratory directors and/or supervisors to assess the hazard levels associated with a particular laser installation and will recommend specific safety procedures for implementation in that situation.

The Table below lists some typical lasers found at BGSU and their classifications.

| Laser Type | Wavelength (nm) | Power (Watts) | Class |
|---|---|---|---|
| He-Ne | 633 | .001 | 2 |
| Argon | 488, 514 | .001 | 2 |
| InGaAlP (diode) | 670 | .001 | 2 |
| | | | |
| Argon | 488, 514 | .001 to .005 | 3R |
| He-Ne | 633 | .001 to .005 | 3R |
| | | | |
| He – Ne | 633 | .01 to .05 | 3B |
| Argon | 488, 514 | <0.5 | 3B |
| Nd:YAG | 1064 | <0.5 | 3B |
| | | | |
| Nd:YaG | 1064,532,355,266 | >0.5 | 4 |
| Argon | 514,488 | >0.5 | 4 |
| Ti:Sapphire | 780 | >0.5 | 4 |
| Dye | 400 to 550 | >0.5 | 4 |
| | | | |

## 3. Acquisition and Registration of Lasers

Any laser of Class 3B or higher laser that is to be used at BGSU must be registered with the Department of Environmental Health & Safety (EH&S). This policy applies whether the instrument is purchased, loaned, obtained through donation, or acquired through other means. EH&S will coordinate the acquisition and registration of all such devices. Before submitting a requisition for purchase of such a device to the Purchasing Department, the request first should be submitted to EH&S accompanied by a written statement that sets forth the basic features of the laser device and its intended use. EH&S will record information needed for institutional records and forward approved requisitions to Purchasing. The director of the laboratory or facility where the laser is to be used is responsible for filing a work plan with the Laser Safety Officer (see below) and for developing a suitable set of instructions or operating procedures for the laser and its intended use prior to installing and using the device.

## 4. Laser Safety Officer

ANSI standards require that a Laser Safety Officer (LSO) be designated by the administration of any educational institution where faculty, staff, or students are involved with the operation of Class 3B or Class 4 lasers. At BGSU, the LSO is designated by the Vice President for Finance and Administration and is a member of the Department of Environmental Health and Safety. The role of the LSO is to administer and manage the overall laser safety program for the institution and to monitor and enforce procedures necessary to minimize laser hazards on campus. The LSO also is responsible for insuring that personnel involved with the use of lasers on campus are properly instructed or trained. Primary responsibilities of the LSO include, but are not limited to, the following:

1. Classify or verify the classification of all lasers on campus consistent with the standards outlined in ANSI Z136.1-2014.
2. Monitor the purchase or acquisition of lasers and maintain a registry of these instruments together with the names of principal users and a description of the intended uses to be made of the respective instruments.
3. Evaluate the hazards of laser work areas and laboratories including
   (a) Establishment of Nominal Hazard Zones (NHZ's) as prescribed in ANSI Z136.1-2014
   (b) Evaluation and approval of Standard Operating Procedures (SOP's) for each laser lab
4. Inspect teaching and research set-ups involving lasers
5. Identify potential hazardous conditions and notify appropriate authorities
6. Discontinue, cancel, or postpone any project until safety conditions are addressed
7. Insure that prescribed controls and procedures are in effect
8. Recommend or approve personal protective equipment (PPE) and related safety items – e.g. eyewear, barriers, screens, clothing, signs, interlocks, etc.
9. Perform periodic audits of PPE, safety procedures, facilities and equipment
10. Approve wording and format of signs and labels displayed in the labs
11. Approve laser installations and equipment prior to initial use or following any physical move or modification of facilities or equipment
12. Ensure adequate training of personnel who work or teach in laser labs
13. Maintain records of training for persons who work with lasers
14. Identify personnel who require medical surveillance and ensure that applicable eye exams are scheduled and performed. Maintain records of same.
15. Investigate accidents involving lasers, make reports, notify appropriate agencies, keep records of such incidents, and institute remedies to any identified problems in safety procedures

## 5. Laser Safety Committee

In addition to the LSO, a Laser Safety Committee (LSC) assists with oversight of the laser safety program and helps to insure that faculty, staff, and students are provided with needed information and understand the hazards associated with lasers or laser systems with which they might work. Membership on this committee includes five representatives selected from the faculty, staff, and student body at BGSU, as follows:

- Laser Safety Officer (ex-officio member and executive secretary for the committee)
- Classified or Contract Staff Representative (appointed by the Vice President for Finance and Administration)
- Faculty members from use departments (two members from different departments; individuals appointed by the department chairs to serve alternate two year terms)
- Student Representative (one graduate student from a department that uses lasers; department representation to be alternated each year)

The Laser Safety Committee is responsible for establishing and reviewing policies and procedures adequate for the control of laser hazards and for recommending appropriate safety

instructions and/or training for faculty, staff, and students. General institutional policies that are recommended and approved by the LSC are incorporated in this program declaration. Safety practices and procedures that are recommended and approved for implementation within a specific laboratory or for a particular laser system are included in a written set of Standard Operating Procedures (SOP) for that laboratory or system. Such SOP's are required for any laboratory or facility that employs a Class 3B or Class 4 laser or laser system. The Laser Safety Officer, in consultation with the Laser Safety Committee, is responsible for reviewing and approving all SOP's for compliance with safety requirements outlined in the ANSI standards and/or with other requirements that may be called for in institutional, state, or federal guidelines. The LSO also is responsible for reviewing and reporting on incidents that occur in facilities where lasers are used and, in cooperation with the LSC and facility directors, for making recommendations for remedy to prevent future occurrence of such incidents.

## 6. Instruction and Training

In conjunction with recommendations of the LSC, and in compliance with regulations specified in ANSI Z136.1, the LSO in cooperation with each facility director will seek to insure that all individuals using Class 3 or 4 lasers receive written instructions in the safe operation and use of such lasers. Individuals who use or operate Class 3B or 4 lasers must complete a medical eye examination prior to employment and a comprehensive training program that, at minimum, includes the following topics:

A. Fundamentals of laser operation (physical principles, construction, etc.)
B. Biological effects of laser radiation on the eye and skin
C. Significance of specular and diffuse reflections
D. Non-beam hazards of lasers
E. Laser and laser system classification
F. Control Measures
G. Overall responsibilities of management and employee
H. Medical surveillance practices (if applicable)
I. Signs and labels for rooms where lasers are located
F. Emergency procedures in case of an accident

## 7. Responsibilities of Laboratory Directors

Faculty members and other BGSU employees who are in charge of the use or maintenance of a laser or laser system that is Class 2 or higher will complete an institutional registration form supplied by the LSO. This form will become part of a permanent institutional registry and contains information about the manufacturer, power, wavelength, date of acquisition, and location of the laser as well as a brief description of its intended use. These registries will be reviewed by the LSO and the Laser Safety Committee, and the information will be used to evaluate the hazard levels of the particular laser system and to make recommendations for safety equipment and procedures to be followed by users of the instrument.

Each director of a research or teaching laboratory where lasers are to be employed is responsible for attending laser safety training offered by the LSO and for seeing that other individuals who

use lasers in his or her laboratory attend such training. Directors of research and teaching laboratories are responsible for developing and implementing a set of Standard Operating Procedures (SOP) for that lab. These SOP's should include basic instructions on safe operation and use of the laser or laser system, including the use of appropriate eyewear and other personal protective equipment, and emergency instructions. Examples of what to include in these SOP's are given on pp. 43-44 of ANSI Z136.5-2000, *Safe Use of Lasers in Educational Institutions*, and these pages are included as an appendix to this document for easy reference. Each SOP should be developed specifically for the laboratory or facility where it is intended to be employed, and each SOP is to be reviewed by the LSO prior to its implementation.

Laboratory directors are responsible for installing any necessary safety devices and for implementing any necessary safety procedures that may be called for in their SOP. For instance, the use of room partitions, safety curtains, beam stops, special eyewear, or other personal protective equipment may be required prior to operation of a given system. The laboratory director is responsible for obtaining these items and insuring their use. Certain restrictions of access or special lockout/tagout procedures also may be necessary. In general, the lab director and the LSO are jointly responsible for insuring that appropriate procedures are put in place for a given lab, that the needed safety equipment has been secured, and that the personnel working there have been properly trained.

Laboratory directors shall report information to the LSO when a laser or laser system is transported to a different location. This will help the LSO keep a running inventory of the location of laser and laser systems throughout Bowling Green State University.

Laboratory directors will immediately report any exposure incident involving lasers to the LSO using the University's standard injury and illness report form.

**8. Authorized Laser Operators**

Persons who operate Class 3B or 4 lasers or laser systems must be authorized by the LSO. Authorization requires demonstration of sufficient knowledge of the laser device and satisfactory completion of basic laser safety training. Operators of Class 3B and 4 lasers must also undergo a baseline eye examination prior to assignment to laser duties. In the event of an accidental or suspected eye exposure to laser radiation, a thorough eye examination will be conducted.

SOP's and laser operator authorization are specific to each laser device. To be authorized as an operator, an individual must complete basic laser training offered by the LSO and satisfactorily demonstrate knowledge of laser fundamentals, basic laser safety principles, and an understanding of the specifics of the SOP that has been designed for the laser in question.

Authorized laser operators will immediately report any exposure incident involving lasers to the LSO using the University's standard injury and illness report form.

# APPENDIX A

## GLOSSARY

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**ANSI** – American National Standards Institute: An institution devoted to the development and dissemination of operating standards that have been developed through a consensus of users and that can be used as a guide for manufacturers, consumers and the general public for the safe operation and use of lasers and laser systems.

**LASER** – Acronym for **l**ight **a**mplification by the **s**timulated **e**mission of **r**adiation. Refers to a device that typically emits radiation in the ultraviolet, visible, or infrared regions of the electromagnetic spectrum, specifically in the wavelength range from 180 nanometers to 1 millimeter.

**LSC** – Laser Safety Committee: A five person committee consisting of faculty, administrative staff, and student representatives charged with overseeing the laser safety program at BGSU and with making recommendations and reviewing policies or procedures for the purpose of protecting the health and safety of persons who work with or around lasers at BGSU.

**LSO** – Laser Safety Officer: A staff member of the department of environmental health and safety who is designated to oversee the laser safety program for BGSU.

**MPE** – Maximum Permissible Exposure: The level of laser radiation to which a person may be exposed without hazardous effects or adverse biological changes in the eye or skin.

**NHZ** – Nominal Hazard Zone: The space within which the level of direct, reflected, or scattered radiation during normal operations exceeds the applicable Maximum Permissible Exposure (MPE). Exposure levels beyond the boundary of the NHZ are below applicable MPE limits.

**PPE** – Personal Protective Equipment: Items such as gloves, lab coats, or eyewear that may help to reduce personal exposure to laboratory hazards. In the case of some lasers, special eyewear is designed to block or attenuate specific wavelengths of radiation to levels below those that would be harmful to the wearer.

**SOP** – Standard Operating Procedures: A set of practical guidelines for safe operating procedures to be followed within the context of a specific laboratory or work environment where lasers are used. SOP's are developed by the laboratory or facility director and reviewed and approved by the LSO and LSC.

# APPENDIX B

## STANDARD OPERATING PROCEDURES

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ANSI Z136.1 recommends written SOPs for activities involving Class 3B lasers and requires written SOPs for Class 4 lasers and laser systems. An SOP is a concise document that gives safety instructions specific for the laser and associated equipment in that laboratory.

### Laser Identification and Characteristics

Department _____ Bldg and Room No. _____

Principal investigator or laboratory director: _____

Office Location _____ Tel: _____ Email _____

Laser type: _____ Class: _____

Manufacturer: _____ Date acquired: _____

Maximum output power (Watts) or maximum energy (Joules): _____

Operational wavelengths (nanometers): _____

Pulsed or continuous wave? _____ Beam diameter (mm): _____

If pulsed, specify frequency and whether single or repetitively pulsed:

Has the nominal hazard zone for this laser been determined? If so, has this area been demarcated and are appropriate barriers in place? Explain with a brief sketch below.

**Hazards associated with this laser (*check all that apply):***

Eye _____ Skin _____ Electrical _____ Air contaminants _____

Other (please describe) _____

**Control Measures**

For each hazard listed above, briefly state the control measures to be used to mitigate injury.

Eyewear: Specify the type of eye and or skin protection to be used

Entryway controls (please describe)

**Hazard Evaluation:** (describe briefly the procedure used to determine nominal hazard zone for this laser) Note: A hazard evaluation is required by ANSI for Class 3B and 4 lasers. This document should be attached or kept on file with your SOP.

Describe any other physical or mechanical controls utilized to minimize hazards – e.g. beam stops, barriers, automatic shut down, etc.

**Alignment Procedures for this laser** (list here or attach)

**De-energizing procedures** (to be used when working on exposed electrical parts)

**Training Requirements** (specify training required of users of this laser)

General laser safety instruction provided by laser safety officer: (yes / no) _____

Special training for operators in this laboratory: (describe content and by whom given)

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

**Approved Operators:** List all individuals authorized to operate this laser without supervision.

# APPENDIX C

## LASER LABORATORY INSPECTION CHECK SHEET

**Laser Laboratory**
**Inspection Check Sheet**

A. Postings and Labeling

1. Appropriate signs (e.g. Class 3B or 4) in place, conveying information about wavelength any required eye protection Yes/No
2. Emergency contact numbers posted conspicuously Yes/No
3. Laser listed on hazards communications poster Yes/No

B. Physical Aspects

1. Is beam appropriately enclosed or blocked? Yes/No
2. Are all beam paths out of eye level? Yes/No
3. Has a nominal hazard zone been identified? Yes/No
4. Are provisions in place to reduce stray reflections? Yes/No
5. Is there a safety interlock system and log of when it is checked? Yes/No

C. Protective eyewear

1. Is appropriate eyewear available and easily accessible? Yes/No
2. Is the optical density (OD) clearly marked on eyewear? Yes/No
3. Is intrabeam or direct viewing of laser beam prevented? Yes/No

D. Procedures

1. Are written protocols available for workers? Yes/No
2. Have all personnel received laser safety training? Yes/No
3. Have personnel completed medical eye exams Yes/No
4. Do written procedures exist for beam alignment? Yes/No
5. Is remote viewing available for invisible beams? Yes/No