IUPUI

LASER SAFETY

MANUAL

Indiana University-Purdue University at Indianapolis
Department of
Environmental Health and Safety
Union Building, Room 043
Indianapolis, IN 46202
Phone 274-2005

August, 2005

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Environmental Health and Safety
Indiana University Purdue University Indianapolis

1.0 INTRODUCTION

It is the policy of Indiana University Purdue University Indianapolis (IUPUI) to support the use of lasers for purposes of research and teaching. The IUPUI Laser Safety Program is designed to provide guidance for the safe use of lasers in research and to help provide for safety of all personnel and visitors that may be exposed to the radiation emitted by lasers. The laser safety policy is based on standards promulgated by the *American National Standard for the Safe Use of Lasers* (ANSI Z136.1), which should be consulted directly for more detailed or specific information, and applies to all lasers and laser systems, whether purchased, borrowed, fabricated, or brought in for use by others.

This manual describes the various components of the IUPUI laser safety program and the specific requirements that must be observed by all users of Class 3b or 4 lasers on the IUPUI campus. In addition, general information on lasers and their associated hazards is included in an online laser safety training program that must be completed by all personnel working with lasers before they can begin working with any class 3b or Class 4 laser. For questions regarding laser safety, contact the Laser Safety Officer at 274-2005.

2.0 RESPONSIBILITIES

In order to ensure the implementation of the requirements of the campus laser safety program, the following responsibilities are designated:

2.1 Laser Safety Officer

The Laboratory Safety Manager who works within the campus Environmental Health and Safety Office shall be designated as the Laser Safety Officer and shall:

- Maintain an inventory of all Class 3b and 4 lasers at IUPUI.

- Review and communicate changes in laser safety requirements through periodic updates to the *Laser Safety Manual*.

- Provide assistance in evaluating and controlling laser hazards.

- Conduct periodic audits to ensure compliance with laser safety requirements.

2.2 Department Chair

The chair of each academic department is responsible for the safety of all individuals working in the department's facilities. The chair fulfills this responsibility by ensuring that all departmental faculty members understand and take seriously their roles in implementing campus safety programs.

2.3 Principal Investigator

Each Principal Investigator whose research involves the use of a Class 3b or 4 laser shall:

- Register each laser with the Laser Safety Officer by completing and submitting Form LS-1 (see Appendix A).

- Enforcement of the safety standards defined in the IUPUI Laser Safety Policy.

- Ensure that the laser is operated safely and in accordance with all university requirements as detailed in the *Laser Safety Manual*.

- Ensure that personal protective equipment (eye wear, protective clothing) is properly maintained and worn.

- Develop, for each laser, a written standard operating procedure that incorporates appropriate safety considerations and requirements.

- Ensure that each laser user has completed the required baseline eye exam, has read the *Laser Safety Manual*, and has taken the online Laser Safety Training course before beginning use of the laser.

- Provide (and require the use of) appropriate eye protection for all laser users.

- Provide specific safety training, appropriate to the use of the laser, to each user.

2.4 Laser User

Each individual who operates a Class 3b or 4 laser shall:

- Complete the required baseline eye exam, read the *Laser Safety Manual*, complete the online Laser Safety Training course and complete the specific training provided by the Principal Investigator before operating the laser.

- Operate the laser safely and in accordance with all requirements contained in the *Laser Safety Manual* and department Standard Operating Procedures.

- Notify the Laser Safety Officer of any conditions that could compromise safety or compliance with university requirements.

- Wear all required Personal Protective Equipment.

3.0 TRAINING

Prior to use of a Class 3b or 4 laser at IUPUI, an individual must complete sufficient and appropriate training to ensure the safe use of this device.

The training should consist of:

- Reading the “Laser Safety Guide”.
- Completion of IUPUI’s Online Laser Safety Training Course.
- Review of operating procedures and emergency procedures.
- Review of the SOP for use and set-up and alignment, if applicable.
- Selection and use of personal protective equipment, if required.
- Identification and proper use of engineering controls.
- Identification of administrative controls, including warning signs and lights.
- Identification of non-laser safety hazards associated with the laser.
- For Laser Controlled Areas in which multiple lasers/wavelengths operate, advising the worker of other laser and non-beam hazards associated with other systems.

4.0 MEDICAL SURVEILLANCE

Each individual who wishes to use a Class 3b or 4 laser at IUPUI, must first complete a baseline eye examination through the Occupational Health Services (call 274-5887 for an appointment)
The examination will include:

- Ocular medical history, including hyperphotosensitive conditions
- Visual acuity 20/20 (6/6 each eye far, Jaeger 1+ near with corrections)

- Macular function (Amsler grid or similar pattern)
- Color vision (Ishihara or similar test)

In the event of a laser exposure incident that involves the eye, the laser user must immediately notify the Laser Safety Officer at (274-2005), report to Occupational Health Services on the first floor of Coleman Hall and arrange for a follow-up eye examination. For exposure incidents that involve the skin or for any exposure incident that occurs after-hours, the laser user should contact (and arrange for transport to) University Hospital Emergency Room and arrange for a follow-up eye examination at Occupational Health Services.

5.0 LASER HAZARD CONTROL MEASURES

IUPUI has adopted as requirements the recommendations of ANSI Z136.1 for hazard control measures for lasers. The ANSI standard specifies various engineering controls, administrative and procedural controls, and protective equipment for lasers and laser systems according to their hazard class. The intent of these controls and equipment is to ensure that the exposure of individuals who work with lasers is at or below the Maximum Permissible Exposure (MPE). Engineering controls typically involve certain physical features or operating characteristics that can be designed into the laser system to ensure safety. Administrative and procedural controls include a wide range of measures such as the development and observance of standard operating procedures and requirements for user training and education. Protective equipment includes both personal protective equipment such as protective eyewear and protective barriers or curtains that surround the laser system. The ANSI standard strongly recommends that engineering control measures be given first priority and that administrative and procedural controls as well as use of protective equipment be employed only as supplemental measures when engineering controls are either impractical or inadequate. A summary of the required control measures is given below.

5.1 Engineering Controls - All Classes

A protective housing with appropriate warning label shall be provided and utilized for all lasers except for certain applications, such as in research and development, where operation of the laser without a housing is necessary.

5.2 Engineering Controls- Class 1

Class 1 lasers require no controls.

5.3 Engineering controls-Class 2

1. A protective housing must be provided.

2. A class II “Caution” logo must be posted on the laser and must read “Do Not Stare Into The Beam”.

3. The laser beam must never be intentionally stared into or directed into the eye.

5.4 Engineering Controls- Class 3a

1. The appropriate "Caution" label must be affixed to the protective housing.

2. Each laser area must be posted with the appropriate "Caution" sign.

3. Any protective housing must remain in place to prevent exposure to radiation from any source other than the defined aperture unless the protective housing interferes with necessary laser operation.

4. The protective housing must be interlocked to prevent exposure of personnel to unnecessary laser radiation. Interlocks must be checked during routine inspections to ensure they are functioning properly. The interlock must not be overridden during normal operation.

5. Beam stops for lasers must be permanently attached and be capable of preventing access to unnecessary laser radiation.

6. Since viewing portals and collecting optics may increase the hazards, all devices must incorporate a means to maintain laser radiation emitted through them at or below safe levels. The laser safety officer or the principal investigator is responsible for determining the hazard involved and is responsible for taking the proper safety measures. Equipment labels must be properly displayed on each laser and must include the class of laser, power output, and the appropriate cautionary statement.

7. Each laboratory must keep written operating, alignment, safety, and emergency procedures. Copies of these documents must be submitted to the laser safety officer upon request. Any changes to any of these procedures must be forwarded to the laser safety officer upon request.

5.5 Engineering Controls - Class 3b and 4

1. A safety interlock shall be provided for any portion of the protective housing which, by design, can be removed during normal operation.

2. Service access panels permitting direct access to laser radiation shall be interlocked or shall require a tool for removal.

3. A key-actuated master interlock shall be provided for system operation.

4. All viewing portals and display screens included as an integral part of the laser system shall incorporate a suitable means (such as interlocks, filters, attenuators) to maintain the laser radiation for all operating conditions at or below the Maximum Permissible Exposure (MPE) limit.

5. The beam should be enclosed to the extent possible for the specific application. Where this is not possible, a Nominal Hazard Zone (NMZ) with appropriate control measures shall be established and observed.

6. A permanently attached beam stop, capable of reducing the laser radiation to levels below the applicable MPE shall be provided at the laser exit port.

7. A warning light or alarm shall indicate laser start-up and operation.

5.6 Additional Engineering Controls - Class 4

1. In situations where the beam is not completely enclosed, operation shall occur only in a light-tight area with interlocked entrances, remote controls, and "panic button" for emergency deactivation of the system.

2. Beam stops shall consist of diffuse-reflecting, fire resistant materials.

3. Adequate ventilation of the operation area shall be provided.

5.7 Administrative/Procedural Controls - Class 3b and 4

1. Written standard procedures for operation, service, and maintenance of the laser system shall be developed and observed.

2. All individuals who will operate or service the laser system shall be provided with training which includes information on the potential hazards of the system and the appropriate controls to be utilized in minimizing these hazards.

3. All entrances to areas with laser systems shall be posted with appropriate warning signs (see Section 6.0 of this manual)

5.8 Protective Equipment

1. Eye protection devices which are specifically designed for protection against radiation from Class 3b and 4 lasers shall be provided to and worn by laser users when engineering or other procedural and administrative controls are inadequate to eliminate potential exposure in excess of the applicable MPE (see Table 5 in the Appendix B for selection criteria).

2. Facility windows that are located within the NHZ of a Class 3b or 4 laser shall be provided with appropriate filter, blocking barrier, or screen that reduces any transmitted laser radiation to levels below the applicable MPE level.

3. A barrier, screen, or curtain that can block or filter the laser beam at the entryway to the NHZ shall be used to prevent laser light from exiting the area at levels above the applicable MPE.

5.9 MINIMAL CONTROL STANDARDS

The majority of lasers and laser systems acquired at IUPUI will be class 1, 2 or 3a lasers that require only minimal control measures, or will involve an "enclosed beam path". If all requirements for protective housing are fulfilled, then enclosed-beam paths, for lasers of all classes, fulfill the requirements of a Class 1 laser and no further controls are required. Standard laser copiers, laser printers, optical scanners or equivalent equipment will be treated as Class 1 lasers unless otherwise noted.

6.0 WARNING SIGNS

Each entrance to an IUPUI facility that contains a Class 3b or 4 laser shall be posted with an appropriate laser warning sign. ANSI Z136.1 recommends that signs and labels conform to a standard design, format, and content. In general, the following information should be included:

1. At position 1 above the tail of the sunburst, special precautionary instructions or protective action such as: *Laser Protective Eyewear Required; Invisible Laser Radiation; Knock Before Entering; Do Not Enter When Light is On; Restricted Area*

   Alternatively, position 1 above the tail of the sunburst can indicated special precautionary instructions or protective actions required by the reader such as:

   A. For Class 2 and Class 3a lasers and laser systems where the accessible irradiance does not exceed the appropriate MPE based

upon a 0.25 second exposure; *Laser Radiation - Do not Stare into Beam or View with Optical Instruments.*

B. For all other Class 3a lasers and laser systems; *Laser Radiation - Avoid Direct Eye Exposure.*

C. For all Class 3b lasers and laser systems; *Laser Radiation - Avoid Direct Exposure to Beam.*

D. For Class 4 lasers and laser systems; *Laser Radiation - Avoid Eye or Skin Exposure to Direct or Scattered Radiation*.

2. At position 2 below the tail of the sunburst, the type of laser (Ruby, Helium-Neon, Nd -YAG, etc.), or the emitted wavelength, pulse duration (if appropriate), and maximum output.

3. At position 3, the class of the laser or laser system.

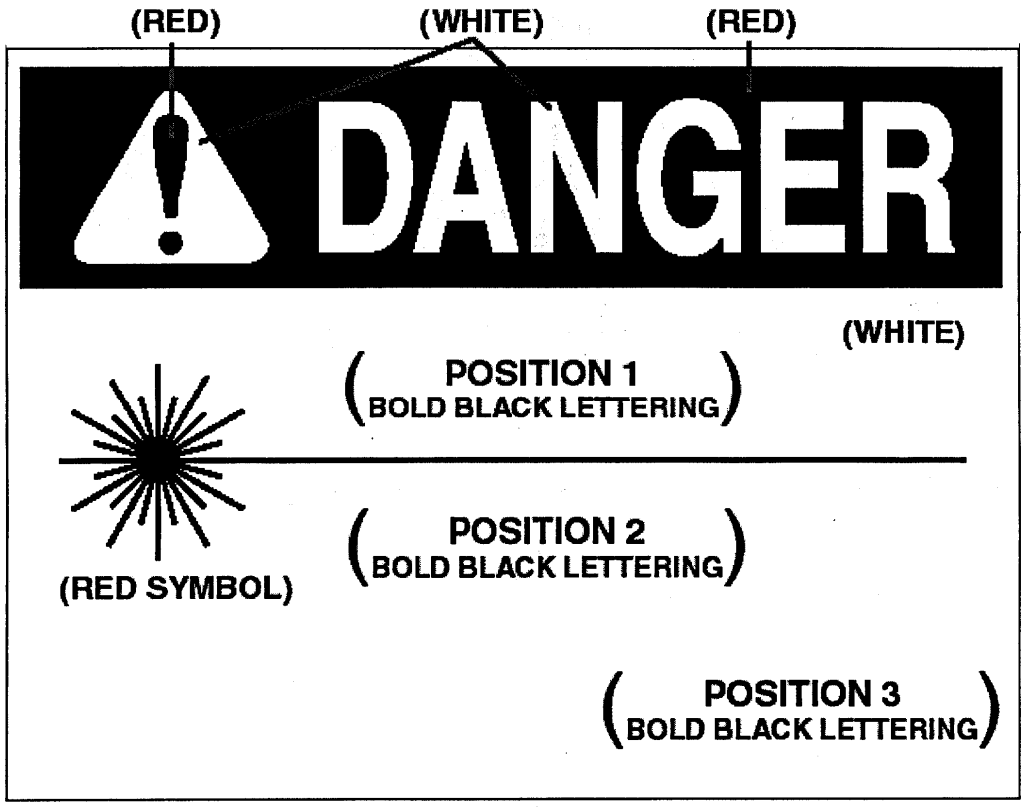

Figure 1. Sample Warning Sign for Certain Class 3a Lasers and for Class 3b and Class 4 Lasers

APPENDICES

TO

LASER SAFETY MANUAL

APPENDIX A

FORMS

Form LS-1

LASER REGISTRATION FORM
IUPUI

Principal Investigator Information

Name:
Department:
Campus Address:
Phone Number:
E-mail Address:

Laser Identification

Type (lasing medium):
Manufacturer:
Model:
Serial Number:
Laser Class (check one): 3b ( ) 4 ( )
Location:

Operating Characteristics

Pulsed	Continuous
Wavelength (nm):	Wavelength (nm):
Maximum Energy (J):	Maximum Power (W):
Minimum Pulse Duration (sec):	

Principal Investigator:_____Date:_____

Submit form to Environmental Health and Safety Office, UN043

APPENDIX B

LASER TYPES

AND WAVELENGHTS

LASER TYPES AND WAVELENGTHS

(ULTRAVIOLET) (100 nm - 400 nm)

Fluorine (diatomic gas excimer) 157
Argon Fluoride (excimer) 193
Krypton Chloride (excimer) 222
Krypton Fluoride (excimer) 248
Xenon Chloride (excimer) 308
Helium Cadmium 325/354
Nitrogen 337.1
Krypton 351/356
Xenon Fluoride (excimer) 351
Argon 351/364

(VISIBLE) (400 nm - 700 nm)

Helium Cadmium (blue) 442
Argon (blue) 458
Helium Selenium (tunable) 460 - 1260
Krypton (blue) 476
Argon (blue) 477
Argon (blue) 488
Rhodamine 6G (tunable dye) 500 - 650
Copper Vapor (green) 511
Argon (green) 515
Krypton (green) 531
Manganese Vapor (green) 534/1290
Helium Neon (green) 544
Erbium: YLF (green) 551
Krypton (yellow) 568
Copper Vapor (yellow) 578
Helium Neon (yellow) 594
Helium Neon (orange) 612
Gold Vapor (red) 628/312
Helium Neon (red) 633
Krypton (red) 647
Gallium Aluminum Arsenide (red diode) 670
Titanium Sapphire (tunable) 670 - 1130
Krypton (red) 676
Ruby (red) 694

(NEAR INFRARED) (700 nm - 1400 nm)

Alexandrite (tunable) 700 - 815
Lead Vapor 723
Krypton 753
Chromium: LiSAF (tunable) 780 - 1010
Gallium Aluminum Arsenide (diode) 840
Calcium Vapor 852/866
Gallium Arsenide (diode) 905
Neodymium: YAG 1064/1320
Barium Vapor 1130/1500
Helium Neon 1152/3390

(FAR INFRARED) (1400 nm - 1 mm)

Erbium: Glass 1540
Holmium: YLF 2060
Thulium: YAG 2010
Holmium: YAG 2100
Erbium: YAG 2490
Erbium: YSGG 2790
Hydrogen Fluoride 4000 - 6000
Carbon Monoxide 5000 - 5500
Carbon Dioxide 9.6/10.6 (um)
Water Vapor 118 (um)
Hydrogen Cyanide 337 (um)

APPENDIX C

GLOSSARY OF

LASER TERMS

Glossary of Laser Terms

Accessible exposure limit (AEL) – The maximum allowed power within a given laser classification.

American National Standards Institute (ANSI) – The technical body which releases the Z136.1 Standard for the Safe Use of Lasers.

Average power – The average power of a pulsed laser is the product of the energy per pulse (J/pulse) and the pulse repetition frequency (Hz or pulses/sec). The average power is expressed in Watts (J/sec).

Coherent radiation – Radiation whose waves are in-phase. Laser radiation is coherent and therefore very intense.

Continuous wave (CW) – A term describing a laser that produces a continuous laser beam while it is operating (verses a pulsed laser beam).

Diffuse reflection – When an incident radiation beam is scattered in many directions, reducing its intensity. A diffusely reflecting surface will have irregularities larger than the wavelength of the incident radiation beam. See specular reflection.

Health Care Laser System (HCLS) – Laser systems used in health care applications, and includes a delivery system to direct the output of the laser, a power supply with control and calibration functions, mechanical housing with interlocks, and associated fluids and gases required for the operation of the laser.

Intrabeam exposure – Exposure involving direct on-axis viewing of the laser beam. Looking into the laser beam would constitute intrabeam exposure. NOTE: Intrabeam viewing of lasers is not permitted on campus.

Infrared (IR) radiation – Invisible radiation with a wavelength between 780 nm and 1 mm. The near infrared (IR-A) is the 780 to 1400 nm band, the mid infrared (IR-B) is the 1400 to 3000 nm band, and the far infrared (IR-C) is the 3000 nm to 1 mm band

Irradiance – The power being delivered over the area of the laser beam. Also called power density, irradiance applies to CW lasers and is expressed in W/cm^2.

Laser – Light **A**mplification by **S**timulated **E**mission of **R**adiation. A monochromatic, coherent beam of radiation not normally believed to exist in nature.

Laser Controlled Area – An area where the occupancy and activity of those within is subject to control and supervision for the purpose of protection from radiation hazards.

Laser User – Any person who uses a laser for any purpose on the IUPUI campus.

Laser Safety Manual – A document defining the IUPUI Laser Safety Program.

Laser Use Registration (LUR) – The mechanism used by the Office of Environmental Health and Safety to track lasers on campus. The LUR details the safety requirements for each Class 3b and 4 laser.

Laser Safety Officer (LSO) – A member of the EHS staff, the LSO is responsible for implementation of the Laser Safety Program.

Maximum permissible exposure (MPE) – The maximum level of radiation which human tissue may be exposed to without harmful effect. MPE values may be found in the IDNS Standard.

Material Safety Data Sheet (MSDS) – A document, required by law, which is supplied by the manufacturer of a chemical. The MSDS details the hazards and protective practices required for protection from those hazards, as well as other information.

Nominal hazard zone (NHZ) – The area surrounding an operating laser where access to direct, scattered or reflected radiation exceeds the MPE.

Optical density (OD) – Also called transmission density, the optical density is the base ten logarithm of the reciprocal of the transmittance (an OD of 2 = 1% transmittance).

Peak power – The highest instantaneous power level in a pulse. The peak power is a function of the pulse duration. The shorter the pulse, the greater the peak power.

Plume – Aerosol created by vaporization of tissue or metals that may contain viable bacteria, virus, cellular debris, or noxious and possibly toxic metallic fumes.

Physician/Principal investigator (P/PI) – The person directly responsible for the laser and its use. The CP/PI has direct responsibility for all aspects of safety associated with the operation of laser systems in either the clinical or laboratory environment.

Radiant exposure – The energy being delivered over the area of the laser beam. Also called energy density, radiant exposure applies to pulsed lasers and is expressed in J/cm2.

Specular reflection – Results when an incident radiation beam is reflected off a surface whose irregularities are smaller than the radiation wavelength. Specular reflections generally retain most of the power present in the incident beam. Exposure to specular reflections of laser beams is similar to intrabeam exposure. See diffuse reflection and intrabeam exposure.

Standard Operating Procedures (SOP) – A procedure that explains operating and safety practices specific to a laser or laser system.

Ultraviolet (UV) radiation – Invisible radiation with a wavelength between 10 nm and 400 nm. The near ultraviolet (UV-A) is the 315 to 400 nm band, the mid ultraviolet (UV-B) is the 280 to 315 nm band, the far ultraviolet (UV-C) is the 100 nm to 280 nm band, and the extreme ultraviolet is the 10 to 100 nm band.

Visible Light – Radiation that can be detected by the human eye. These wavelengths are between 400 and 780 nm. The colors (with approximate wavelengths) are: Violet (400 – 440 nm), Blue (440 – 495 nm), Green (495 – 545 nm), Yellow (545 – 575 nm), Orange (575 – 605 nm), and Red (605 –780 nm).