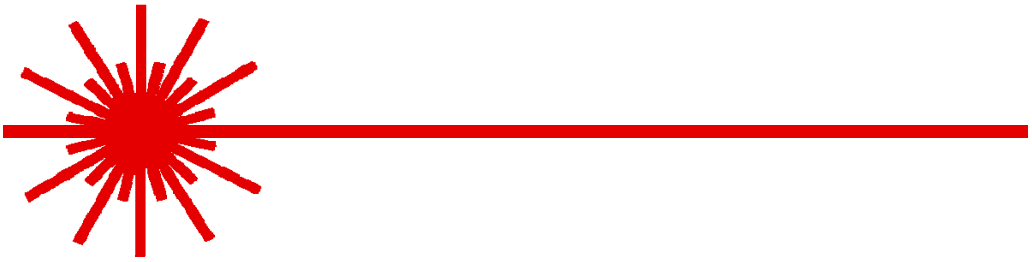
LASER SAFETY MANUAL
FOR LASER USERS



ISSUED BY

WESTERN KENTUCKY UNIVERSITY
DEPARTMENT OF ENVIRONMENT, HEALTH & SAFETY

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POLICY and SCOPE

The primary objective of the Western Kentucky University (WKU) laser safety program is to ensure that no laser radiation in excess of the maximum permissible exposure (MPE) limit reaches the human eye or skin. Additionally, the program is designed to ensure that adequate protection against collateral hazards is provided. These collateral hazards include, but are not limited to, the risk of electrical shock, fire hazard from a beam or from use of dyes and solvents, chemical exposures from use of chemicals and vaporization of targets, and the emission of ionizing and non-ionizing radiation from power supplies associated with the operation of the laser or laser system.

WKU requires that all Class 3b and Class 4 lasers and laser systems be operated in accordance with the American National Standards Institute (ANSI) Z136.1-2000, "Safe Use of Lasers" and other applicable federal and state regulations. To that end, WKU adopts ANSI Z136.1-2000 as its laser safety program. Exceptions to this standard will be considered on a case-by-case basis by the Laser Safety Officer (LSO). The LSO shall document and keep record of any policy decisions that are exceptions to the ANSI Z136.1-2000 standard.

All Class 3b and Class 4 laser operations at WKU shall be registered with, reviewed and approved by the WKU LSO. The LSO shall subsequently notify the Kentucky Supervisor of Radiation Producing Machines, Radiation Health Branch, Cabinet for Health and Family Services, Department of Public Health, of any Class 3b and Class 4 lasers or laser systems possessed by Western Kentucky University. The LSO shall also notify this person of the disposal of any Class 3b or Class 4 lasers or laser systems. Though not required by this policy, guidance is available from the LSO and in ANSI Z136.1-2000 for Class 1, Class 2, and Class 3a lasers.

This manual shall be available for reference by all laser users at WKU. It is the responsibility of the Laser Supervisor to maintain this manual for reference purposes. All persons using lasers shall be familiar and comply with all requirements of this manual.

ORGANIZATION OF THE LASER SAFETY PROGRAM

Laser Safety Officer (LSO)

The Laser Safety Officer (LSO) is an individual that will effect the knowledgeable evaluation and control of laser hazards, and have the responsibility and authority to monitor and enforce the control of laser hazards. At the current time, the LSO shall be WKU's Radiation Safety Officer. In an effort to make the laser safety program effective, the LSO will be given authority to accompany the responsibility of the position. The Laser Safety Officer at Western Kentucky University is granted this authority by its President.

The LSO shall be designated for all circumstances of operation, maintenance, and service of a Class 3b or Class 4 laser or laser system.

LSO Specific Responsibilities

- Classification or verification of laser classification for Class 3b or Class 4 lasers or laser systems
- Hazard evaluation of laser areas, including Nominal Hazard Zones (NHZ)
- Recommendation or approval and auditing of functionality of control measures
- Approval of Standard Operating Procedures (SOPs) and alignment procedures
- Provide guidance for proper protective eyewear, barriers, etc.
- Provide appropriate warning signs for posting and labeling
- Approve of laser facilities, laser equipment, and modification of existing prior to use
- Conduct periodic safety audits of laser facilities and equipment
- Assist Laser Supervisors with safety education and training
- Determine need for medical surveillance
- Additional
    - Provide or cause to provide consultative services on laser hazard evaluation and controls and on personnel training programs
    - Establish and maintain adequate policies/procedures for the control of laser hazards
    - Suspend, restrict, or terminate laser or laser system operation if laser hazard controls are determined inadequate
    - Maintain records of all Class 3b and Class 4 lasers and laser operators
    - Survey by inspection all areas where laser equipment is used and ensure corrective action is taken where required
    - Participate in accident investigations involving lasers
    - Approve laser or laser systems for operation

Laser Safety Committee

At this time, it is not considered necessary to create a formal Laser Safety Committee at Western Kentucky University due to the limited number of Class 3b and Class 4 lasers and laser systems. However, the LSO will consult with various laser-knowledgeable people for the review of Laser Registrations and for the consideration of laser issues as deemed necessary by the LSO.

Laser Supervisor

The laser supervisor will be knowledgeable of the requirements for laser safety, the potential laser hazards and associated control measures for all lasers and laser systems, education and all policies, practices and procedures pertaining to laser safety at locations under the supervisor's authority.

The laser supervisor will

1. comply with the requirements of the Laser Safety Manual and the LSO
2. provide training on laser hazards and their control to all personnel who may work with lasers under his/her jurisdiction
3. write and be familiar with the standard operating procedures for Class 3b and Class 4 lasers and ensure that these procedures are provided to users of such lasers
4. not permit the operation of a laser unless there is adequate control of laser hazards to employees, visitors, and the general public
5. submit the names of individuals scheduled to work with lasers to the LSO
6. submit information as requested by the LSO for medical surveillance and training completion
7. immediately notify the LSO of known or suspected accidents resulting from lasers operated under his/her authority
8. not permit operation of a new or modified laser under his/her authority without approval of the LSO
9. make sure that plans for laser installation or modifications of installations are submitted to the LSO for approval

Laser User

Laser Users include faculty members, researchers, graduate and undergraduate students, operators, technicians, engineers, maintenance and service personnel, and any other personnel, working with or around lasers.

Laser Users shall use laser equipment in accordance with this Laser Safety Policy, ANSI Z136.1-2000 and direction from his/her Laser Supervisor and the LSO. A laser user will not energize or work with or near a laser unless authorized to do so by the supervisor for that laser. The laser user will be familiar with all operating procedures.

When a laser user knows or suspects that an accident has occurred involving that laser, or a laser operated by another employee, and that such accident has caused an injury or could potentially have caused an injury, he or she will immediately inform the supervisor. If the supervisor is not available, the employee will notify the LSO.

CONTACT INFORMATION

Emergencies and Incident Procedures

Persons receiving or suspected of having received a harmful laser beam or non-beam hazard exposure must report such a fact or suspicion immediately to his/her Laser Supervisor and the LSO.

The LSO can be reached at:

WKU Office (Regular Business Hours 8:00 a.m. – 4:30 p.m.): 745-7095
WKU Cell (Anytime): 779-6601

The Laser Supervisor's contact information shall be posted in a conspicuous location in the laser area.

For emergencies, call 911 or 5-2548 from campus phones to reach the WKU Police. The WKU Police will contact the appropriate emergency response agency.

Collateral Hazards

There are multiple potential collateral hazards associated with the use of lasers and laser systems. These hazards include, but are not necessarily limited to electrical, collateral radiation, fire, hazardous chemicals (dyes, solvents, flue and smoke filters, etc.), and laser generated air contaminants.

The following individuals will be the primary contact in WKU Environment, Health & Safety if you have questions regarding these collateral hazards.

Fire Safety/Fire Extinguisher Selection
Fire Safety Officer, 745-2931
Hazardous Waste Disposal
Environmental Compliance Specialist, 745-6366
Chemical Hazards/Air Contaminants/Lock-out|Tag-out
Lab Safety Officer, 745-3168
Radiation Safety
Radiation Safety Officer, 745-7095

REGISTRATION OF LASERS AND LASER USERS

All class 3b and 4 lasers must be registered with the LSO in WKU Environment, Health & Safety prior to installation and use. This may be accomplished by completing the laser registration form in Appendix B.

All class 3b and 4 laser users must be registered with Environment, Health & Safety prior to working with class 3b or 4 lasers. The laser user registration form is located in Appendix C.

APPENDIX A: ANSI Z136.1-2000 Safe Use of Lasers

ANSI Z136.1-2000 Safe Use of Lasers is incorporated by reference. Contact the LSO at 745-7095 for information on ordering a copy of this standard.

The LSO has one copy of this standard and can loan it out for short periods of time.

APPENDIX B: LASER REGISTRATION FORM

Western Kentucky University
Department of Environment, Health & Safety

Instructions: All Class 3b and 4 lasers are required to be registered with the WKU Laser Safety Officer. Complete this form for each laser to be registered and forward to:

Laser Safety Officer, Environment, Health & Safety, FAX: 5-5037

User Information

Laser Supervisor: _____ Phone: _____

Laser Supervisor: _____ Phone: _____

Other Laser User: _____ Phone: _____

Other Laser User: _____ Phone: _____

Other Laser User: _____ Phone: _____

Laser Information

Laser Manufacturer: _____

Model Number: _____

Serial Number: _____

Laser Location: _____
Department Building Room Number

Laser Status: ☐Operable ☐Inoperable ☐Stored ☐Other _____

Laser Type (Nd:YAG, CO_2, etc): _____

Classification (3b or 4): _____

Wavelength (nm): _____

*Beam Diameter at Exit of Laser(mm): _____

Beam Divergence (mrad): _____

☐ Continuous Wave: Average Power (Watts): _____

or

☐ Pulsed: Pulse Energy: _____ (Joules per pulse)

Pulse Duration: _____ (Seconds)

Pulse Repetition Frequency _____ (Hz)

or

☐ Q-switched Pulse Width: _____ Energy: _____ (Joules per pulse)

Purpose or Use: _____

*Note: Report the beam diameter at 1/e. If the beam diameter is reported by the manufacturer at $1/e^2$, then you can calculate 1/e by the following equation:

$$\frac{1}{e} = \frac{\frac{1}{e^2}}{\sqrt{2}}$$

Comments:

_____ _____

Laser Supervisor's Signature Date

APPENDIX C: LASER USER REGISTRATION & TRAINING INFORMATION

Instructions: All users of Class 3b and 4 lasers are required to be trained and registered with the WKU Laser Safety Officer prior to using said lasers. Complete this form and forward to:

Laser Safety Officer, Environment, Health & Safety, FAX: 5-5037

Name: _____ Phone: _____

Department: _____ Building/ Room #: _____

Laser Supervisor: _____

List all laser or laser safety training course work you have completed. Note all the titles, dates completed, duration (hours of course) and locations.

Title	Date Completed	Duration of Training	Location of Training

Signature: _____ Date: _____

(Laser User)

Signature: _____ Date: _____

(Laser Supervisor)

APPENDIX D: STANDARD OPERATING PROCEDURE TEMPLATE & EXAMPLE

Template

1. Introduction – Description of Laser
    - Type and wavelength
    - Intended application
    - Location
    - Average power or pulse energy
    - Pulse duration and repetition rate for pulsed lasers
    - Beam diameter and divergence
2. Hazards – List all hazards associated with laser
    - Eye and skin hazards from direct and diffuse exposures
    - Electrical hazards
    - Laser generated air contaminants
    - Other recognized hazards
3. Control Measures – List control measures for each hazard
   Include the following:
    - Eyewear requirement, include wavelength and OD
    - Description of controlled area and entry controls
    - Reference to equipment manual
    - Alignment procedures (or guidelines)
4. Training Requirements
    - State the specific training requirements of approved personnel
5. Emergency Procedures
    - List action to be taken in case of emergency and personnel to be contacted
6. Approved Personnel
    - List by name all individuals who are approved to operate the laser in a class 4 state (may be maintained separately)

Example SOP

Scope: This SOP applies to all activities in which there is potential access to the laser beam.

1. System Description: Model 1000 ND:YAG laser marker system manufactured by the XYZ Company. This is a Class 1 laser system with an embedded Class 4 laser.

   Wavelength: 1.064 um
   Pulse Duration: 100 ns
   Pulse Repetition Rate: 5,000-20,000 Hz
   Average Power: 30 W
   Beam Diameter: 4 mm
   Beam Divergence: 2 mrad

2. Hazards
   Eye hazard from direct, reflected or scattered beam
   Skin hazard and fire hazard
   Electrical haza4rd inside power supply
   Laser Generated Air Contaminants

3. Control Measures
   Establish Laser Controlled Area using laser barrier and warning signs. Approved laser safety eyewear with OD = 5.0 @ 1064 nm is required for all personnel inside the controlled area. Block beam with diffuse reflecting beam block. See equipment manual for beam alignment procedures.

   Keep all combustibles, tool, and reflective surfaces away from the beam path. Make sure you know where the beam is and stay clear.

   Work involving access to the power supply is normally done with the system locked out. Access to the energized power supply must be done only by qualified personnel using the "buddy" System. Workers are directed to review the electrical safety and power supply sections of the manual before any activities involving access to high voltage.

   When functioning normally, the exhaust system will remove all LGACs even with the protective housing open. Notify the LSO if you think there might be a problem.

4. Required Training: Laser Safety training is required before personnel will be authorized to be in the controlled area awhile the beam is acc3essible.

5. Emergency Procedures:
   In case of emergency, notify Laser Supervisor at _____
   For emergency medical response call _____
   Report all incidents to the LSO at _____

6. Authorized Personnel
   The following personnel are authorized to operate this system in a class 4 condition: (list)

APPENDIX E: NOTE ON MEDICAL SURVEILLANCE

In ANSI Z136.1-2000, Section 6, medical surveillance is required for users of Class 3b and Class 4 lasers and laser systems. Per communication at an LSO training session on July 21, 2005, provided by Rockwell Laser Industries, ANSI Z136.3-2005 "Safe Use of Lasers in Educational Institutions", changes medical surveillance from a requirement to a recommendation for these classes of lasers. It was also indicated that the forthcoming revision of ANSI Z136.1 will also make this change.

To this end, medical surveillance is recommended, not required, for Class 3b and Class 4 laser or laser system users at WKU.

APPENDIX F: SUMMARY OF TRAINING

Table D 1

Suggested Training for LSOs and Employees (Including, but Not Limited to, Operators, Maintenance Personnel, and Service Technicians) Routinely Working with or around Lasers

	Employees					LSOs (1)
Highest-Class Laser	1	2	3a	3b	4	
Manufacturers Guide and Operating Manuals	R	SR	SR	SR	SR	n/a
Safety Guide Literature (2)	A	A	R	SR	SR	SR
Audio/Video and/or Non-interactive Computer Based Instruction (3) (4)	A	R	R	SR	SR	SR
Interactive Computer Instruction (7)	A	R	R	SR	SR	SR
Laser Safety Orientation (4) (5)	A	A	A	R	SR	SR
Short-Term Course (4) (6)	n/a	n/a	n/a	n/a	R	SR
Overview of Applicable Standards	n/a	n/a	n/a	R	SR	SR
Working Knowledge of Content and Implementation of Applicable Standards	–	–	–	–	–	SR
Laser Safety Conferences/Symposia	n/a	n/a	n/a	n/a	n/a	SR

n/a = not applicable
R = recommended
SR = strongly recommended
A = Suggested for Awareness

Notes:

(1) Where the suggested training vehicles for the LSO are deemed inappropriate for reasons of very low potential hazards or very limited use of lasers, substitute training vehicles may be used. Regardless of the training vehicles used, the LSO's training must enable him or her to fulfill the requirements and responsibilities of an LSO as outlined in Dl.1 through Dl.8 and Section 1.3 for all lasers under the LSO's jurisdiction.

(2) Pamphlet or booklet of basic laser safety information. Although education is not a requirement for Class 2 and Class 3a lasers, overview or guideline pamphlets or brochures provide a low-key basic guide to the general topic of laser safety.

(3) Audio/Visual programs may be stand-alone or used in conjunction with other media. Computer-based programs may also be stand-alone. Computer-based training may be used for very basic instructions up to comprehensive multiple lesson courses.

(4) There are many providers of laser training materials and formal instructional courses. Many of these providers advertise their products and services in the trade and professional society publications. They are often listed in the annual buyer's guide of the various publications.

(5) A Laser Safety Orientation course may include the previously mentioned vehicles. Because of the greater potential hazards from Class 3b and 4 lasers, the duration of the course would be from several hours to a day or two. This training may be conducted by outside specialists if not available internally.

(6) Short-term courses may run from a day or two to any length required. Because of the high level of potential hazards to both eye and skin for Class 4 lasers, the training should be complete and cover all applicable topics described in D6.2.

(7) Interactive computer-based programs are available on CD or Laser video disks, and will be available on the world wide web (internet).

Refresher Training

Refresher training will be provided as determined by the LSO, but no less than every two years.

APPENDIX G: SUMMARY OF CONTROL MEASURES

Table 10

Control Measures for the Four Laser Classes

Control Measures	Classification				
Engineering Controls	1	2	3a	3b	4
Protective Housing (4.3.1)	X	X	X	X	X
Without Protective Housing (4.3.1.1)	LSO shall establish Alternative Controls				
Interlocks on Protective Housing (4.3.2)	∇	∇	∇	X	X
Service Access Panel (4.3.3)	∇	∇	∇	X	X
Key Control (4.3.4)	—	—	—	•	X
Viewing Portals (4.3.5.1)	—	MPE	MPE	MPE	MPE
Collecting Optics (4.3.5.2)	MPE	MPE	MPE	MPE	MPE
Totally Open Beam Path (4.3.6.1)	—	—	—	X NHZ	X NHZ
Limited Open Beam Path (4.3.6.2)	—	—	—	X NHZ	X NHZ
Enclosed Beam Path (4.3.6.3)	None is required if 4.3.1 and 4.3.2 fulfilled				
Remote Interlock Connector (4.3.7)	—	—	—	•	X
Beam Stop or Attenuator (4.3.8)	—	—	—	•	X
Activation Warning Systems (4.3.9.4)	—	—	—	•	X
Emission Delay (4.3.9.1)	—	—	—	—	X
Indoor Laser Controlled Area (4.3.10)	—	—	—	X NHZ	X NHZ
Class 3b Indoor Laser Controlled Area (4.3.10.1)	—	—	—	X	—
Class 4 Laser Controlled Area (4.3.10.2)	—	—	—	—	X
Laser Outdoor Controls (4.3.11)	—	—	—	X NHZ	X NHZ
Laser in Navigable Airspace (4.3.11.2)	—	—	•	•	•
Temporary Laser Controlled Area (4.3.12)	∇ MPE	∇ MPE	∇ MPE	—	—
Remote Firing and Monitoring (4.3.13)	—	—	—	—	•
Labels (4.3.14 and 4.7)	X	X	X	X	X
Area Posting (4.3.9)	—	—	•	X NHZ	X NHZ

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

Table 10 (cont.)

Control Measures for the Four Laser Classes

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

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

REFERENCES

ANSI Z136.1 (2000) American National Standard for Safe Use of Lasers. Copyright 2000, Laser Institute of America.

Laser Registration Form, Duke University, http://www.safety.duke.edu/RadSafety/laser.asp, 2005.

Laser Safety Manual, University of Kentucky, http://ehs.uky.edu/radiation/laserman.html, 1999.

Laser Safety Officer L-222 Course Overheads, Control Measures, Section i, SOP Guidelines, Rockwell Laser Industries, Inc., 2004.