



LASER SAFETY POLICY MANUAL



ISSUED BY

**ENVIRONMENTAL HEALTH & SAFETY
OFFICE OF RADIOLOGICAL SAFETY
and
GEORGIA TECH LASER SAFETY COMMITTEE**

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Georgia Institute of Technology

Stephen E. Cross, Ph.D., Executive Vice President for Research

MEMORANDUM

July 1, 2010

TO: Dr. Michael Nicovich, Chair
Institute Laser Safety Committee

FROM: Nazia Zakir, Radiation Safety Officer
Office of Radiological Safety

SUBJECT: LASER SAFETY COMMITTEE AUTHORITY MEMORANDUM

The Georgia Institute of Technology has established a Laser Safety Committee (LSC) to create, implement, and maintain a laser safety program with the assistance of a Laser Safety Officer (LSO). The LSC and LSO have the administrative responsibility for laser activities and laser safety issues at the Institute.

This Laser Safety Committee shall:

- be composed of faculty and staff who by their knowledge and experience are qualified to make judgments and recommend policy in the area of laser safety.
- establish, approve and maintain policies, procedures and guidance for the control of laser hazards.
- have the authority to suspend, restrict, and terminate the operation of a laser if it is deemed that the laser hazard controls are inadequate or in the event of any accident or injury.
- review applicable new or revised laser safety standards and determine how to incorporate them into the laser safety program.
- review reportable occurrences (such as laser injury) and take appropriate corrective actions.

The Laser Safety Officer shall:

- assist the Laser Safety Committee with its responsibilities.
- have the authority to monitor and enforce the control of laser hazards at Georgia Tech.
- have the authority to suspend, restrict, or terminate the operation of a laser system if it is deemed that laser hazard controls are inadequate.

A Laser Safety Policy Manual was approved by the Laser Safety Committee on April 30, 2010. This manual details requirements for users of Class 3B and 4 lasers at Georgia Tech and is based on the American National Standards Institute Z136.1 Safe Use of Lasers and the State of Georgia regulations in 290-5-27.01 - .06.

The requirements of this Laser Safety Policy Manual have the authorization of the Office of the Executive Vice President for Research. Knowledge of and adherence to these procedures is the responsibility of every individual who uses Class 3B and 4 lasers. Laser users shall cooperate with the Laser Safety Committee and Laser Safety Officer in the implementation of these requirements.

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1. POLICY AND SCOPE

The primary objective of the Georgia Institute of Technology (Georgia Tech) laser safety program is to ensure that no laser radiation in excess of the maximum permissible exposure (MPE) limit reaches the human eyes or skin. An additional objective is to ensure that adequate protection against non-beam hazards (NBH) is provided. These NBH include, but are not limited to, electric shock, fire hazards, laser generated air contaminants, chemical exposures, and collateral non-laser radiation (NLR).

To achieve these objectives, Georgia Tech requires that all Class 3B and Class 4 lasers and lower class systems containing embedded Class 3B and Class 4 lasers (embedded lasers), be operated in accordance with the American National Standards Institute (ANSI) Z136.1-2014, "Safe Use of Lasers", other applicable Z136 standards, and any applicable federal and state regulations. This laser safety program applies to all Georgia Tech locations in the U.S., including mobile and temporary field locations.

A Laser Safety Committee (LSC) exists to oversee the laser safety program with the help of the Laser Safety Officer (LSO). While their main purpose is to educate and assist laser users in the safe use of lasers, the LSC and LSO have been given the authority to suspend, restrict, or terminate the operation of a laser if it is deemed that laser hazard controls are inadequate or in the event of an accident or injury. This authority is granted by the Executive Vice President for Research.

This policy manual shall be available for reference by all Laser Users (LUs) at Georgia Tech. It is available on the website of the Environmental Health and Safety (EHS) department's Office of Radiological Safety (ORS). All LSs and LUs shall be familiar and comply with the requirements herein.

Georgia Tech adopts ANSI Z136.1-2014 and Z136.8-2012 as the basis of its laser safety program. Exceptions to the ANSI standard will be considered on a case-by-case basis by the LSO and LSC. The LSO shall document any policy decisions that are exceptions to applicable standards.

For additional information or assistance, contact the LSO at EHS ORS at laser@ehs.gatech.edu.



2. ACRONYMS/ABBREVIATIONS/DEFINITIONS

2.1. Acronyms/Abbreviations

AEL – Accessible Emission Limit
ANSI – American National Standards Institute
CW – Continuous Wave Laser
EHS – Environmental Health & Safety
Hz – Hertz
IR - Infrared
J - Joule
LCA – Laser Controlled Area
LEP – Laser Eye Protection
LHA – Laser Hazard Assessment
LS – Laser Supervisor
LSs – Laser Supervisors
LSC – Laser Safety Committee
LSO – Laser Safety Officer
LU – Laser User
LUs – Laser Users
MPE – Maximum Permissible Exposure
NBH – Non-Beam Hazards
NHZ – Nominal Hazard Zone
NLR – Non-Laser Radiation
NOHD – Nominal Ocular Hazard Distance
OD – Optical Density
ORS – Office of Radiological Safety
PPE – Personal Protective Equipment
PRF – Pulse Repetition Frequency
SOP – Standard Operating Procedure
TL – Threshold Limit
UV – Ultraviolet
VLT – Visible Luminous Transmission
W - Watt

2.2. Definitions

- 2.2.1. Embedded laser – Any enclosed Class 1, 2, 3a or 3R system that contains a Class 3B or Class 4 laser inside the enclosure. The lower classification of the enclosure is due to engineering control measures that prevent access to the Class 3B or Class 4 laser radiation during normal operation.
- 2.2.2. Laser controlled area – a laser use area where the occupancy and activity of individuals is controlled and supervised by a Laser Supervisor. Potentially hazardous beam exposure is possible in this area.



- 2.2.3. Maximum permissible exposure – the level of laser radiation to which an unprotected person can be exposed without suffering adverse biological changes in the eye or skin.
- 2.2.4. Nominal Hazard Zone – The area within which the MPE may be exceeded due to direct, reflected, or scattered radiation.



3. RESPONSIBILITIES AND ORGANIZATION

This section informs Laser Supervisors (LSs) and Laser Users (LUs) of their roles and responsibilities in helping provide a safe laser use environment at Georgia Tech. Also addressed are the roles and responsibilities of the Laser Safety Committee, Laser Safety Officer, Purchasing Department, and Other Personnel.

3.1. LASER USER (LU)

3.1.1. A Laser User (LU) is any individual that will operate, maintain, or service a laser under the supervision of a Georgia Tech Laser Supervisor.

3.1.2. Requirements to be completed prior to operating a Class 3B or Class 4 laser, or maintaining/repairing an embedded laser (see also [Appendix F](#)) include:

3.1.2.1. Training

3.1.2.1.1. Complete Georgia Tech laser safety training.

3.1.2.2. Authorization via LU-1

3.1.2.2.1. Complete and submit Form LU-1, Laser User Registration, to the LSO.

3.1.2.2.2. An LU must submit a Form LU-1 for each LS for whom he/she is working.

3.1.2.2.3. LUs are not required to complete a Form LU-1 if operating an embedded laser under normal operating conditions.

3.1.2.2.4. An LU that will maintain/service an embedded laser shall complete and submit a Form LU-1.

3.1.3. Responsibilities of an LU

3.1.3.1. An LU shall comply with the safety rules and procedures prescribed by the LS, LSO, LSC, and this manual, with the LSC having final authority should a disagreement arise. He/she shall be familiar with all operating procedures applicable to his/her work. Intentional exposure of personnel to laser radiation is prohibited.

3.1.3.2. An LU shall promptly report all injuries and accidents involving lasers to the LS and the LSO. However, the treatment of injured personnel and the preservation of property shall be the first priorities.

3.2. LASER SUPERVISOR (LS)

3.2.1. A Laser Supervisor (LS) is a Georgia Tech faculty or staff member that has primary responsibility for any operation/maintenance/repair of a Class 3B, Class 4, or embedded laser.



3.2.2. It is expected that the LS know the paperwork and training requirements, the potential laser hazards and associated control measures, and all operating procedures pertaining to laser safety for lasers under his/her control.

3.2.3. Requirements to be completed prior to becoming an LS:

3.2.3.1. Training

3.2.3.1.1. Complete Georgia Tech laser safety training.

3.2.3.2. Application for LS status via LS-1

3.2.3.2.1. Complete Form LS-1, Laser Supervisor Registration, provide your signature as the LS, and submit the form to the LSO.

NOTE: LSs must complete a Form LS-1 even if they will be operating/supervising an embedded laser only under normal operating conditions.

3.2.4. Responsibilities of a LS

3.2.4.1. Training

3.2.4.1.1. The LS shall ensure that LUs operating/maintaining/servicing his/her lasers complete laser safety training offered by ORS as specified in 3.1.2.

3.2.4.1.2. The LS shall ensure that operational training is provided to LUs.

3.2.4.1.3. The LS shall complete refresher training every 2 years. This refresher training shall be completed whether or not the possessed lasers are in active use.

3.2.4.1.3.1. If the LS has not completed the required refresher training within 6 months of the initial due date, the LSC Committee Chair will be notified.

3.2.4.1.3.2. If the LS has not completed the required refresher training within 9 months of the initial due date, the Department Chair will additionally be notified.

3.2.4.1.3.3. If the LS has not completed the required refresher training within 12 months of the initial due date, all lasers under the LS's supervision will be tagged as inactive, use not allowed, and a retake of the initial laser safety training required before use is allowed to resume.

3.2.4.2. Supervision of Laser Users



3.2.4.2.1. The LS shall determine which individuals are authorized to operate a laser under his/her control. The LS shall ensure that these individuals submit the Laser User Registration, Form LU-1. LUs operating an embedded laser under normal conditions do not need to submit Form LU-1.

3.2.4.3. Accidents and Injuries

3.2.4.3.1. The LS shall notify the LSO of known or suspected laser-related accidents and injuries. If necessary, the LS will assist in obtaining appropriate medical attention for any individual involved in the laser accident.

3.2.4.3.2. The LS shall refer to Section 10 of this document for guidance on Georgia Tech worker's compensation and other injury reporting.

3.2.4.3.3. The LS shall cooperate with the LSO and/or LSC during the course of their investigation and implement corrective actions to prevent a recurrence. A written incident report shall be prepared by the LS within 1 month of the incident. Refer to Section 10 of this document for more detailed instructions.

3.2.4.4. Acquisition of Class 3B, Class 4, and Embedded Lasers

3.2.4.4.1. The LS should notify the LSO of any Class 3B or 4 laser acquisition prior to placing the order or otherwise arranging for its receipt (e.g., donations, loans, etc.).

3.2.4.4.2. Complete and submit a Form LR-1, Laser Registration, for each Class 3B, Class 4, or embedded laser.

3.2.4.5. Operating Procedures

3.2.4.5.1. The LS shall ensure that written standard operating procedures (SOPs) are developed for Class 3B and Class 4 lasers. The SOP shall include procedures for emergency response and for alignment, maintenance, and service as applicable. The written SOPs shall be kept with the laser for reference.

3.2.4.5.2. The LS must train all LUs under his/her supervision on all laser SOPs/operating procedures at their laser facility.



3.2.4.5.3. See [Appendix C](#) for instructions on accessing a laser SOP template.

3.2.4.6. Laser Laboratory Self-Audits

3.2.4.6.1. If requested by the LSO, the LS or designated LU shall conduct a self-audit of their laser laboratories and lasers according to the format provided by the LSC and LSO.

3.2.4.7. Response to Laser Safety Inspection Deficiencies

3.2.4.7.1. The Laser Supervisor, or their Laser User designee, shall document corrective actions for deficiencies identified during laser safety inspections as instructed by the LSO.

3.2.4.7.1.1. If the corrective actions have not been implemented and documented within 1 month of the initial due date, the LSC Committee Chair will be notified.

3.2.4.7.1.2. If the corrective actions have not been implemented and documented within 2 months of the initial due date, the Department Chair will additionally be notified.

3.2.4.7.1.3. If the corrective actions have not been implemented and documented within 3 months of the initial due date, all lasers under the LS's supervision will be tagged as inactive and use not allowed until implementation and documentation have been completed.

3.2.4.8. Notification of Laser Laboratory Changes

3.2.4.8.1. The LS shall notify the LSO of any pending laser relocations, laser lab renovations, etc. prior to the activities taking place.

3.3. Laser Safety Committee (LSC)

3.3.1. Membership

3.3.1.1. The LSC shall be composed of faculty and staff who by their knowledge and experience are qualified to make judgments and recommend policy in the area of laser safety. The LSO is an ex-officio member of the LSC.

3.3.1.2. Members shall be appointed to the LSC for periods of up to three years on staggered terms. Membership is limited to two consecutive terms. After two terms, a three year absence from LSC membership is required. Appointments will be based on calendar years.

3.3.1.3. A quorum will consist of a simple majority of voting LSC members.



3.3.1.4. The chairperson of the LSC and the LSO cannot be the same person.

3.3.2. Scope

The LSC shall establish and maintain policies, procedures, and guidance for the control of laser hazards at Georgia Tech.

3.3.3. Authority

The LSC has the authority to suspend, restrict, or terminate the operation of a laser project if it is deemed that the laser hazard controls are inadequate or in the event of any accident or injury. This authority is granted by the Executive Vice President for Research of Georgia Tech.

3.3.4. Standards

The LSC will review applicable new or revised ANSI laser safety standards for incorporation into the laser safety program.

3.3.5. Responsibilities

3.3.5.1. The LSC shall meet semiannually and when situations arise that need attention.

3.3.5.2. Approvals by the LSC are signified by the receipt of a simple majority vote of approval by the voting members of the LSC. Approval votes may be submitted via e-mail.

3.3.5.3. The LSC shall review and approve laser policy for Georgia Tech. Minor modifications to supporting forms which do not change the original intent of the policy may be approved by the LSO. Individuals on the LSC will serve as technical content experts providing consultation to the LSO.

3.3.5.4. The LSC shall review reported injuries, injury near misses, unique concerns resulting from laser hazard assessments, or issues otherwise brought to the LSC's attention. The LSC shall take appropriate action as necessary.

3.3.5.5. Minutes of the LSC meetings, including any recommendations or occurrences, shall be recorded and distributed to all LSC members. LSC minutes will be filed in the ORS office.

3.3.5.6. The LSC may delegate authority to the Chairperson or a subcommittee to act in its behalf between normal meeting dates in certain matters. In such a case, at the next meeting of the LSC, the full membership will review the action and provide any additional guidance.

3.3.5.7. The LSC shall review and approve all revisions to the Laser Safety Policy Manual.

3.4. LASER SAFETY OFFICER (LSO)

3.4.1. Appointment



3.4.1.1. The LSO shall be appointed by the Assistant Vice President of Environmental Health & Safety and the Radiation Safety Officer.

3.4.2. Responsibilities

3.4.2.1. The LSO will work with the individual LS to ensure the safety standards of each laser laboratory are adequate.

3.4.2.2. Training Programs

3.4.2.2.1. The LSO shall ensure laser safety training is available for each individual routinely operating a Class 3B or Class 4 laser. A comprehensive laser safety training program is available from the ORS. See <https://ehs.gatech.edu/radiation/laser/training> for details.

3.4.2.3. Registration

3.4.2.3.1. The LSO shall register all Class 3B and Class 4 lasers with the Georgia Department of Community Health using information provided by the LS.

3.4.2.4. Records

3.4.2.4.1. The LSO will ensure that appropriate records regarding laser safety are maintained.

3.4.2.4.2. The LSO shall periodically contact the LS to ensure the laser inventory is current.

3.4.2.4.3. The LSO shall periodically contact the LS to verify the list of LUs is current.

3.4.2.5. Laser Hazard Assessments

3.4.2.5.1. The LSO shall ensure that a Laser Hazard Assessment (LHA) is conducted for each laser/laser use area. This process may include the verification of laser class and will result in the specification of control measures, such as LEP, barriers, etc.

3.4.2.6. Audits and Inspections

3.4.2.6.1. The LSO or designee will periodically audit areas where Class 3B, 4, and embedded laser equipment is used.

3.4.2.6.2. The LSO will accompany regulatory agencies inspecting the laser facility.

3.4.2.6.3. The LSO will ensure that corrective action is taken where required.

3.4.2.7. Accidents and Injuries



- 3.4.2.7.1. Upon notification of a known or suspected laser-related accident or injury, the LSO shall investigate the accident or injury and take appropriate action.
- 3.4.2.7.2. The LSO shall perform a hazard evaluation of the laser facility to determine the cause of the accident, interview individuals involved in the accident, and make certain that necessary controls have been implemented before operation resumes. The LSO has the authority to suspend operations until a full investigation has been completed.
- 3.4.2.7.3. The LSO shall report to the Georgia Department of Community Health, in writing, any injury, regardless of severity or extent, sustained in the course of operating, handling, servicing, or manufacturing a laser within fifteen (15) days of detection of the injury.

3.4.2.8. Program Recommendations

- 3.4.2.8.1. The LSO shall make policy and procedure recommendations to the LSC.

3.4.3. Authority

- 3.4.3.1. The LSO has the authority to monitor and enforce the control of laser hazards at Georgia Tech and to suspend, restrict, or terminate the operation of a laser project if it is deemed that the laser hazard controls are inadequate or in the event of any accident or injury. This authority is granted by the Executive Vice President of Georgia Tech.

3.5. GEORGIA TECH PURCHASING DEPARTMENT

- 3.5.1. The Georgia Tech Purchasing Department will inform the LSO, to the best of its ability, of all orders for lasers. Notification should be in the form of a copy of the Purchasing Requisition or Purchase Order. The LSO will contact the LS to provide guidance for the implementation of the appropriate laser safety control measures.

3.6. OTHER PERSONNEL

- 3.6.1. Personnel involved with the building, renovation, rehabilitation, etc. of any space intended for laser use, shall contact the LSO during the design stage for input on control measures that may be best purchased and installed as part of those processes. These personnel include Building Managers, Design and Construction Project Managers, etc.



4. TRAINING

4.1. Laser Safety Training

All LSs shall be trained in the safe use of lasers prior to beginning work with Class 3B, Class 4, or embedded lasers. All LUs shall be trained in the safe use of lasers prior to beginning work with Class 3B and Class 4 lasers. LUs are recommended but not required to complete laser safety training if they are only operating an embedded laser under normal conditions.

Laser safety training is offered by ORS via an online training program. Refresher training will be required periodically. Individuals that are due for refresher training will be notified by e-mail.

The LSO shall also periodically complete laser safety refresher training.

Laser safety training shall include at least the following topics

- 4.1.1. Fundamentals of laser operation (physical principles, construction, etc.)
- 4.1.2. Bioeffects of laser radiation on the eye and skin
- 4.1.3. Significance of specular and diffuse reflections
- 4.1.4. Non-beam hazards of lasers
- 4.1.5. Laser classifications
- 4.1.6. Control measures
- 4.1.7. Overall responsibilities of management and employees
- 4.1.8. Medical examination practices (if applicable)

An awareness level presentation is available for individuals who work in the vicinity of lasers, but are not themselves laser users.

Links to both laser safety training and laser awareness training can be found on the EHS website at <https://ehs.gatech.edu/radiation/laser/training>.

4.2. Operational Training

Laser Supervisors shall provide Laser Users with operational training for each Class 3B or Class 4 laser they will use under their supervision. It is essential that new or less involved Laser Users be provided with operational training by an individual fully aware of the nature of the work and the hazards involved.

Operational training is also required for users of embedded lasers. Documentation of the training is strongly recommended. This documentation is best accomplished by having the LU sign the SOP document for a given laser.



5. CONTROL MEASURES

Control measures are designed to reduce the possibility of eye and skin exposure to laser radiation in excess of the applicable Maximum Permissible Exposure (MPE) limit and other hazards associated with the lasers.

The MPE is the maximum safe exposure without hazardous effect or adverse biological changes in the eye or skin. The MPE depends upon the wavelength and exposure duration. The MPE is not affected by physical changes in the laser experiment layout. The Nominal Hazard Zone (NHZ) is the distance at which laser exposure may exceed the MPE. For a given laser, changes in the laser power level, beam diameter, beam divergence and the MPE will affect the NHZ.

Control measures are classified as engineering, administrative, and personal protective equipment (PPE). Engineering controls are always the preferred method to provide for safety. Administrative controls and PPE are to be used only where the engineering controls are inadequate or impractical. It is common that all types of control measures are required for a given laser.

An important consideration when implementing control measures is to distinguish between operation, maintenance, and service of the laser. Control measures are to be based on the normal operation of the laser. When either maintenance or service is performed, it is often necessary to implement additional control measures. This often applies to the maintenance or service of embedded lasers.

The remainder of this section contains more details for the control measure requirements and recommendations for Class 3B, Class 4, and embedded lasers. Each item contains a bracketed reference to the section of the ANSI standard from which the item was summarized and a listing of the laser types for which it is required or recommended. The LSO may substitute alternate control measures that provide equivalent protection. There may be some instances in which the LSC has chosen to adopt an ANSI recommendation as a requirement.

See [Appendix D](#) for a tabulated top-level summary of control measures.

See [Appendix F](#) for additional information regarding embedded lasers.



5.1. Engineering Control Measures

Engineering control measures are designed or incorporated into the laser or laser setup.

5.1.1. Protective Housings

5.1.1.1. A protective housing shall be present and in good condition. At its most basic, the protective housing is the cylinder, box, etc. that encloses the laser's optical cavity and light pump.

[Z136.1-2014, 4.4.2.1 – Required 3B, 4, and Embedded]

5.1.1.2. A laser shall be operated without a protective housing only if the LSO has specified alternate control measures.

[Z136.1-2014, 4.4.2.1.1 and Z136.8-2012, 4.2.1 – Required 3B and 4]

5.1.2. Interlocked Protective Housings for Embedded Systems

5.1.2.1. Embedded lasers shall have a protective housing that is interlocked with fail-safe or redundant interlocks. If the housing is opened or removed, the beam must be automatically interrupted to prevent exposure of an individual.

[Z136.1-2014, 4.4.2.1.2 – Required Embedded]

5.1.2.2. Only for embedded systems being developed in-house, an acceptable alternative to the interlocked protective housing is a housing that requires a tool to remove and having an appropriate warning label on the panel/covering.

[Z136.8-2012, 4.2.2 – Allowed Embedded]

5.1.3. Service Access Panels

5.1.3.1. Service access panels that allow access to Class 3B or 4 radiation shall be interlocked or removable only with a tool and be labeled with appropriate hazard language.

[Z136.1-2014, 4.4.2.1.4 – Required 3B, 4, and Embedded]

5.1.4. Equipment Labeling

5.1.4.1. All lasers shall have appropriate warning labels and other equipment labels. If the laser and laser control are separated by more than 2 meters, then the labels must be on both.

[Z136.1-2014, 4.6.6 – Required 3B, 4, and Embedded]

5.1.5. Master Switch

5.1.5.1. Lasers should be provided with a master switch.

[Z136.1-2014, 4.2.2.2 – Recommended 3B, 4, and Embedded]

5.1.5.2. All energy sources associated with Class 3B or Class 4 lasers shall be designed to permit lockout/tagout procedures required by OSHA.

[Z136.1-2014, 4.4.2.2 – Required 3B, 4, and Embedded]

5.1.6. Viewing Windows and Display Screens



- 5.1.6.1. Viewing windows and diffuse (reflective or transmitted) display screens included as an integral part of a laser shall use interlocks, filters, attenuators, etc., as a means to keep the laser radiation at the viewing position at or below the MPE.
[Z136.1-2014, 4.4.2.3 – Required 3B, 4, and Embedded]

5.1.7. Facility Windows

- 5.1.7.1. If a facility window is located within the NHZ, and the beam isn't otherwise prevented from reaching the window, it shall be covered to reduce any transmitted radiation to levels below the MPE. The window barrier shall exhibit a damage threshold for beam penetration for a specified exposure time commensurate with the total hazard evaluation. Unless a laser protective window was sold as an integral part of the laser, it shall be labeled with the optical density and wavelength for which it applies.
[Z136.1-2014, 4.4.2.4 – Required 3B and 4]

5.1.8. Laser Protective Barriers and Curtains

- 5.1.8.1. A blocking barrier, screen, or curtain that can block or filter the beam at the entryway should be used to prevent radiation from exiting the area at levels above the MPE. Laser barriers shall be specifically selected to withstand direct and diffusely scattered beams. The barrier shall exhibit a damage threshold for beam penetration for a specified exposure time commensurate with the total hazard evaluation for the facility and specific application. All laser barriers sold other than as an integral part of a product shall be labeled with the barrier exposure for which the limit applies and the beam exposure conditions under which protection is afforded.
[Z136.1-2014, 4.4.2.5 – Required 3B and 4]
- 5.1.8.2. Laser barriers purchased for use that are not laser rated by the vendor may be tested by the end user according to ANSI Z136.7-2008, American National Standard for Testing and Labeling of Laser Protective Equipment with approval of the LSO. In addition to meeting this testing standard, the chosen barrier material shall be flame retardant as shown by testing conducted by the vendor. The exception is for metal barriers which are inherently flame retardant.

5.1.9. Collecting Optics

- 5.1.9.1. All collecting optics, such as lenses, telescopes, microscopes, etc. that integrate the use of a laser shall incorporate suitable means to maintain the laser radiation transmitted through the collecting optics to levels at or below the applicable MPE. Items like interlocks, filters, and attenuators are useful for this. Permanently mounted collecting optics housing containing laser protective filters shall be labeled with the optical density and wavelength to which it applies.
[Z136.1-2014, 4.4.2.6 – Required 3B and 4]

5.1.10. Beam Paths



5.1.10.1. Control of the beam path shall be accomplished as described below.

[Z136.1-2014, 4.4.2.7 – Required 3B, 4, and Embedded]

5.1.10.1.1. If the beam path is fully open a laser hazard evaluation shall be conducted
[Z136.1-2014, 4.4.2.7.1 – Required 3B and 4]

5.1.10.1.2. If the exposed path of the beam is limited a laser hazard evaluation shall be conducted.
[Z136.1-2014, 4.4.2.7.2 – Required 3B and 4]

5.1.10.1.2.1. If the hazard assessment defines an extremely limited NHZ and procedural controls can provide adequate protection, Class 1 conditions will be considered met.
[Z136.1-2014, 4.4.2.7.2.1]

5.1.10.1.3. If the beam path is fully enclosed, and the enclosure meets all requirements of a protective housing, then the laser setup will be designated Class 1 and no other control measures will be necessary. If the beam enclosure is temporarily opened (such as during service or repair) then appropriate control measures shall be implemented.
[Z136.1-2014, 4.4.2.7.3 – Required 3B and 4]

5.1.11. Area Warning Device.

5.1.11.1. A warning light shall be visible prior to entering a laser controlled area. The light serves to warn that a laser is emitting radiation or is about to emit radiation. Examples are a red light or a lighted laser in use light box.

[Z136.1-2014, 4.4.2.8 – Required 4, Recommended 3B]

5.1.12. Laser Radiation Emission Warning

5.1.12.1. The laser control panel shall have a light that indicates a laser is emitting or is about to begin emitting radiation.

[Z136.1-2014, 4.4.2.9 – Required 4, Recommended 3B]

5.1.12.2. If the laser radiation emission warning light is not easily visible throughout the controlled area, a separate warning light that is easily visible should be installed in the area.

[Z136.1-2014, 4.4.2.9.1 – Recommended 3B and 4]

5.1.13. Class 4 Laser Controlled Area Engineering Controls

5.1.13.1. Access

All area or entryway safety controls shall be designed to allow both rapid egress by laser personnel at all times and admittance to the laser controlled area under emergency conditions.

[Z136.1-2014, 4.4.2.10.1, Required 4]



5.1.13.2. Emergency Conditions

There shall be a clearly marked "Emergency Stop" or other appropriately marked device (remote controlled connector or equivalent device) suitable for the intended purpose of deactivating the laser or reducing the output to levels at or below the MPE.

[Z136.1-2014, 4.4.2.10.2, Required 4]

5.1.13.3. Entryway Controls

In addition to other control measures specified, all Class 4 laser controlled areas shall incorporate one of the following options.

[Z136.1-2014, 4.4.2.10.3, Required 4]

5.1.13.3.1. Non-Defeatable Area or Entryway Safety Controls.

5.1.13.3.1.1. Non-defeatable entryway interlocks shall be used to deactivate the laser or reduce the output to levels at or below the applicable MPE in the event of unexpected entry into the laser controlled area.

5.1.13.3.1.2. No individual shall be able to defeat the interlock.

5.1.13.3.2. Defeatable Area or Entryway Safety Controls.

5.1.13.3.2.1. Defeatable entryway interlocks shall be used if non-defeatable area/entryway safety controls limit the intended use of the laser.

5.1.13.3.2.2. Entry shall be permitted only if there is clearly no laser radiation hazard at the point of entry and adequate PPE is provided.

5.1.13.3.2.3. The ability to defeat the entryway interlocks shall only be provided registered LSs and LUs.

5.1.13.3.3. Procedural Area or Entryway Safety Controls.

Where safety latches or interlocks are not feasible or are inappropriate the following shall apply:

5.1.13.3.3.1. All personnel with access shall be adequately trained (Laser Safety training for LSs and LUs; Laser Awareness training for non-laser users) and adequate PPE shall be provided upon entry.

5.1.13.3.3.2. Laser radiation at the entry shall be below the MPE, which can be accomplished with the installation of laser barriers, curtains, etc.

5.1.14. Scanning Devices



5.1.14.1. Scanning devices shall incorporate a means to prevent laser emission if scan failure or other failure resulting in a change in either scan velocity or amplitude would result in exposures above the MPE. [Z136.1-2014, 4.4.2.11, Required 3B and 4]

5.1.15. Outdoor Control Measures

5.1.15.1. All lasers used outdoors shall meet the requirements found in ANSI Z136.6 [Z136.1-2014, 4.4.2.12].

5.1.15.2. See Section 7 for additional information on Outdoor Laser Use.

5.2. Administrative (Procedural) Control Measures

Administrative controls are rules or work practices used to help reduce the laser exposure hazard potential.

5.2.1. Standard Operating Procedures (SOP)

5.2.1.1. Written SOPs shall be written and maintained for the operation, maintenance, or service of Class 3B and Class 4 lasers. SOPs shall also be written for the maintenance or service of embedded lasers. [Z136.8-2012, 4.3.1 – Required 3B, 4, and Embedded]

5.2.1.2. Written SOPs are recommended by Georgia Tech for the operation of embedded lasers.

5.2.2. Education and Training

5.2.2.1. Laser safety training shall be completed by all LSs, LUs, and maintenance and service personnel for Class 3B or Class 4 lasers, as well as for embedded lasers where beam access is required during maintenance and/or service. [Z136.1-2014, 4.4.3.3 – Required 3B and 4, Required Embedded for maintenance and service]

5.2.2.2. The LSO has the right to request proof of laser safety training from outside vendors/contactors that are on site for installation, maintenance, or service activities. The LSO may restrict these activities if the outside vendor/contractor is unable to provide this proof.

5.2.2.3. On-the-job training (OJT) operational training shall be provided by the LS for all LUs operating, maintaining, or servicing a Class 3B or Class 4 laser, for all LUs maintaining or servicing an embedded laser, and for all individuals engaged in normal operation of embedded lasers. This is best documented by having the LUs sign the back page of the written SOP for each given laser. [Z136.8-2012, 5.6 – Required 3B and 4, Required Embedded for maintenance and service]

5.2.3. Authorized Personnel



- 5.2.3.1. Class 3B and Class 4 lasers shall be operated, maintained, or serviced only by registered LUs authorized by registered LSs.
[Z136.1-2014, 4.4.3.4 – Required 3B and 4]
- 5.2.3.2. Embedded lasers shall be operated only by individuals authorized by the LS.
- 5.2.3.3. Embedded lasers shall be maintained or serviced only by registered LUs authorized by registered LSs.
[Z136.1-2014, 4.4.3.4 – Required Embedded]
- 5.2.4. Indoor Laser Controlled Area
 - 5.2.4.1. A laser controlled area shall be established for Class 3B and Class 4 use areas.
[Z136.1-2014, 4.4.3.5 – Required 3B and 4]
 - 5.2.4.2. A temporary laser controlled area shall be established if an embedded laser is operated in a manner that provides access to the Class 3B or Class 4 laser radiation.
[Z136.1-2014, 4.4.3.5]
 - 5.2.4.3. Laser controlled areas shall:
[Z136.1-2014, 4.4.3.5.1 – Required 3B and 4]
 - 5.2.4.3.1. Allow laser operation only by personnel who have been trained in laser safety and in the operation of the laser.
 - 5.2.4.3.2. Be posted with the appropriate area warning sign(s). See [Appendix G](#) for examples.
 - 5.2.4.3.3. Be operated in a manner such that the beam path is well defined.
 - 5.2.4.3.4. Require the appropriate laser eye protection for personnel within the laser-controlled area.
 - 5.2.4.4. A laser controlled area shall:
[Z136.1-2014, 4.4.3.5.1 – Recommended 3B, Required 4]
 - 5.2.4.4.1. Be under the direct supervision of an individual knowledgeable in laser safety.
 - 5.2.4.4.2. Be located so that access to the area by spectators is limited and requires approval by the LS.
 - 5.2.4.4.3. Have any potentially hazardous beam terminated in a beam stop of an appropriate material.
 - 5.2.4.4.4. Have only diffusely reflecting materials in or near the beam path, where feasible.
 - 5.2.4.4.5. Have all windows, doorways, open portals, etc., from an indoor facility either covered or restricted in such a manner as to reduce the



transmitted laser radiation to levels at or below the applicable ocular MPE.

- 5.2.4.4.6. Require storage or disabling (e.g., removal of the key or lock-out/tag-out) of the laser when not in use to prevent unauthorized use.

5.2.5. Spectators and Laser Controlled Areas

- 5.2.5.1. Spectators should not be permitted within a laser controlled area that contains a Class 3B laser and spectators shall not be permitted within a laser controlled area that contains a Class 4 laser unless the following conditions have been met.

[Z136.1-2014, 4.4.3.7 – Recommended 3B, Required 4; Z136.8-2012, 4.4.1 – Required 3B and 4]

- 5.2.5.1.1. Appropriate approval from the LS has been obtained

- 5.2.5.1.2. Direct supervision is provided by an experienced, trained LU

- 5.2.5.1.3. The degree of hazard and how to avoid the hazard(s) have been explained to the spectator(s). This shall include an explanation of what a Nominal Hazard Zone (NHZ) is and what the NHZ is for the lab.

- 5.2.5.1.4. Appropriate protective measures are taken (e.g., barriers are in place to prevent direct viewing of the beam or hazardous diffuse reflections, proper LEP has been provided, etc.)

- 5.2.5.2. The SOP shall describe the conditions for visitors and spectators in Class 3B and Class 4 Laser Controlled Areas.

[Z136.1-2014, 4.4.3.7 – Recommended 3B, Required 4], [Z136.8-2012, 4.4.1 – Required 3B and 4]

5.2.6. Alignment Procedures

- 5.2.6.1. Laser incident reports have repeatedly shown that an ocular hazard may exist during beam alignment procedures. Alignment of Class 3B or Class 4 laser optical systems (e.g., mirrors, lenses, beam deflectors) shall be performed in such a manner that the primary beam, or a specular or diffuse reflection of a beam, does not expose the eye to a level above the applicable MPE.

- 5.2.6.2. Written SOPs outlining alignment methods shall be written for Class 3B and Class 4 lasers. Alignment SOPs shall also be written for all classes of lasers that contain embedded Class 3B or Class 4 lasers under conditions that would allow access during alignment procedures.

[Z136.1-2014, 4.4.3.8 – Required 3B, 4, and Embedded]



5.2.6.3. See [Appendix H](#) and the [Laser Standard Operating Procedure \(SOP\) Template](#) for alignment procedure guidelines.

5.2.7. Service Personnel

5.2.7.1. Personnel who require access to Class 3B or Class 4 lasers or laser systems enclosed within a protective housing or protected area enclosure shall comply with the appropriate control measures of the enclosed or embedded laser or laser system.
[Z136.1-2014, 4.4.3.9 and Z136.8-2012, 4.3.6 – Required 3B, 4, and Embedded]

5.3. Personal Protective Equipment (PPE)

5.3.1. Laser Eye Protection (LEP)

5.3.1.1. LEP shall be used where the potential exists for exposure to Class 3B or Class 4 laser radiation.
[Z136.1-2014, 4.4.4.1 – Required 3B and 4]

5.3.1.2. The Visible Luminous Transmission (VLT) should be considered when eyewear is specified. Attempts should be made to use eyewear with a VLT of at least 20%, while also maintaining the correct OD.
[Z136.1-2014, 4.4.4.2.4 and Z136.8-2012, 4.5.2.6 – Recommended 3B and 4]

5.3.2. Alignment Eyewear

The main ocular hazard during alignment procedures is the improper use of fully protective LEP products that fully attenuate the point source diffused (non-specular) visible beam such that alignment viewing is not possible. In these cases, LEP is typically removed, or not worn, for beam alignment, which increases the potential for eye injury.

5.3.2.1. When alignment eyewear is needed, the LSO shall recommend LEP that meets the minimum OD requirement for viewing an ideal, point-source, diffuse reflection at a distance of 20 cm. Alignment eyewear that uses OD less than fully protective shall be used only after consultation with the LSO.

[Z136.1-2014, 4.4.4.2.5 and Z136.8-2012, 4.5.2.10 – Required 3B, 4, and Embedded], [Z136.1-2014, 4.4 - Required 3B, 4, and Embedded].

5.3.3. Labeling of Laser Eyewear Protection

5.3.3.1. All LEP shall be clearly labeled with the OD and wavelength for which protection is afforded.
[Z136.1-2014, 4.4.4.2.6 and Z136.8-2012, 4.5.2.7 – Required All LEP]

5.3.3.2. Labeling shall not be done by the Laser Supervisor or Laser User. If the manufacturer-provided labeling is no longer readable, contact the LSO for labeling to be applied.

5.3.4. Cleaning and Inspection of Laser Eyewear Protection



5.3.4.1. Periodic cleaning and inspection shall be performed on LEP to ensure they are maintained to a satisfactory condition. The frequency of the safety inspection should be once per year.
[Z136.1-2014, 4.4.4.2.7 and Z136.8-2012, 4.5.2.8 – Required All LEP]

5.3.5. Review of Purchase of Laser Eye Protection

5.3.5.1. Purchasers of LEP should require that the following information accompanies each item.
[Z136.1-2014, 4.4.4.2.8 and Z136.8-2012, 4.5.2.9 – Recommended All LEP]:

5.3.5.1.1. Wavelength(s) and corresponding OD for which protection is afforded

5.3.5.1.2. Pertinent data such as damage threshold for laser safety purposes

5.3.5.1.3. Manufacturer's recommendations on shelf life, storage conditions, cleaning and use

5.3.6. UV Laser Skin Protection

5.3.6.1. Exposure to UV radiation shall be minimized by using beam shields and clothing that attenuate the radiation to levels below the applicable MPE for the specific UV wavelengths. In some laser applications, such as use of excimer lasers operating in the ultraviolet wavelengths, the use of a skin cover shall be employed if chronic (repeated) exposures are anticipated at exposure levels at or near the applicable MPEs for skin. If the potential exists for a damaging skin exposure, particularly for ultraviolet lasers (295 nm to 400 nm) and/or laser welding/cutting application, then skin-covers and/or "sun screen" creams are recommended.
[Z136.1-2014, 4.4.4.3.1 – Required 3B and 4]

5.3.6.2. PPE shall be used when working with open beam Class 3B or Class 4 UV lasers. This shall include both eye and skin protection.
[Z136.1-2014, 4.4.4.3.1 – Required 3B and 4]

5.3.7. PPE Damage

Note that PPE may have serious limitations when used with higher-power Class 4 lasers; for example, the protective equipment may not adequately reduce or eliminate the hazard and may be damaged by the incident laser radiation.
[Z136.1-2014, 4.4.4.1]

5.4. Laser Warning Signs

5.4.1. Laser warning signs shall be posted at the entryway to a laser controlled area.
[Z136.1-2014, 4.4.3.5.1 – Required 3B and 4]



- 5.4.2. Laser warning signs shall be posted at outdoor laser use areas and describe the NHZ.
[Z136.1-2014, 4.4.3.6.1 – Required 3B and 4]
- 5.4.3. Laser warning signs shall be in the format specified in the ANSI Z535 series of standards.
[Z136.1-2014, 4.6.1 – Required 3B and 4]
- 5.4.4. Laser warning signs shall use the “Warning” and “Danger” signal words as described in [Appendix G](#).
[Z136.1-2014, 4.6 – Required 3B and 4]
- 5.4.5. The message panel on the warning sign shall indicate the laser class of the controlled area, laser eye protection requirements (including wavelength and OD), the presence of invisible laser radiation, information regarding the meaning of any lighted warning light, and contact information for the LSO.
[Z136.1-2014, 4.6.3.4 – Required 3B and 4]
- 5.4.6. A “Notice” sign shall be posted with the laser warning sign at a temporary laser controlled area. The area around an embedded laser may be considered a Class 3B or 4 temporary laser controlled area during maintenance or service.
[Z136.1-2014, 4.6.1.3 – Required 3B, 4, and Embedded]

5.5. Laser Optical Fiber Use

- 5.5.1. Optical fiber transmission is considered to take place in an enclosure, where the fiber is considered part of the enclosure.
[Z136.1-2014, 4.5.2 and Z136.8-2012, 4.4.3]
- 5.5.1.1. If the process of disconnecting a fiber connector reduces the emitted radiation below the MPE, the disconnection may take place in an uncontrolled area with no other controls required.
[Z136.8-2012, 4.4.3]
- 5.5.1.2. If the MPE is exceeded when a fiber is disconnected, a laser controlled area must be established and appropriate control measures used. The connector shall have a label or tag that reads “Hazardous Laser Radiation when Disconnected” or similar.
[Z136.8-2012, 4.4.3 – Required 3B, 4, Embedded]
- 5.5.2. Fiber Optic Safety Guidelines
[Z136.8-2012, 4.4.3.3]
- 5.5.2.1. Always work with fiber optic cables as if they are active/live.
- 5.5.2.2. Do not look straight in to the end of a fiber.
- 5.5.2.3. The NHZ from a fiber with a micro lens is similar to that of a collimated beam.
- 5.5.2.4. Make sure fibers are terminated into an instrument (power meter) or suitable end caps.
- 5.5.2.5. Because of glass particle hazards, do not touch your eyes while performing fiber connectorizing or splicing work. Do not touch



contact lenses until you are sure your hands are clean. Always wash your hands before touching your eyes.

- 5.5.2.6. Do not eat in the same area you are working. Always wash your hands before eating. Particles of glass from an optical fiber are like splinters and can cause internal hemorrhaging.
- 5.5.2.7. The fiber strands are extremely sharp and can easily penetrate your skin or eye. When broken off they are very hard to find and remove.
- 5.5.2.8. Properly label all fibers in conduit and jacketed fiber (bare fibers may not accept labeling).



6. Non-Beam Hazards

There are number of potential non-beam hazards associated with laser use. These are any hazard resulting from the presence of a laser that is not directly the result of exposure to the direct or scattered laser radiation. The LSO may refer the end user to other offices within the Department of Environmental Health and Safety for assistance in accomplishing appropriate control of non-beam hazards.

Non-beam hazards can include, but are not necessarily limited to:

Physical Agents

- Electrical Hazards
 - Electric shock
 - Resistive Heating
 - Electric Spark Ignition of Flammable Materials
 - Arc Flash
- Non-Laser Radiation (NLR)
 - Radiofrequency Radiation
 - Flashlamp Light Leakage
 - X-Rays from High Voltage Equipment
- Fire Hazards
 - Materials likely to be exposed to irradiances above 10 W/cm^2
 - Materials likely to be exposed to beam powers exceeded 0.5 W
 - Irradiances above 0.5 W/cm^2 (per NFPA)
- Explosion Hazards
 - High pressure arc lamps
 - Filament lamps
 - Capacitor banks
- Noise
- Fiber Optic Fragment Hazards
- Nanoparticles

Chemical Agents

- Compressed Gases
- Laser Dyes and Solvents

Laser Generated Air Contaminants (LGAC)

- Chemical air contaminants released when a beam interacts with a material
- Airborne infectious material that results from beam interaction with tissue or samples

Miscellaneous Non-beam Hazards

- Laser-related waste (disposal of dyes, solvents, smoke filters, etc.)
- Degradation/Malfunction of Laser Cooling Systems
- Violating Building Codes (local fire codes, ventilation controls, chemical storage, etc.)



7. Outdoor Laser Use

7.1. General Requirements

- 7.1.1. The LSO shall be contacted if any outdoor laser use is planned.
- 7.1.2. The LSO will conduct a laser hazard analysis and indicate the necessary control measures necessary for protecting both the laser operators and any members of the public potentially impacted by the outdoor laser use.

7.2. Federal Aviation Administration (FAA) Requirements

- 7.2.1. The FAA is responsible for regulating the use and efficient utilization of navigable airspace to ensure the safety of aircraft and the protection of people and property on the ground. The LSO will assist with the calculations for and submission of the forms that must be submitted to the FAA prior to the outdoor laser use.
- 7.2.2. The LS shall provide all pertinent information requested by the LSO for the calculations and shall prepare all supporting documents (such as standard operating procedures) that will be included with the submission of the FAA forms.

7.3. Food and Drug Administration (FDA) Requirements

- 7.3.1. All outdoor (and indoor) laser light show demonstrations that use Class 3B or Class 4 lasers to create visible open beams shall be reported to the FDA. The LSO will assist with the calculations for and submission of the forms that must be submitted to the FDA prior to the conduct of the laser light show demonstration.
- 7.3.2. The LS shall provide all pertinent information requested by the LSO for the calculations and shall prepare all supporting documents (such as standard operating procedures) that will be included with the submission of the FDA forms.



8. Laser Pointers

When low power laser pointers are used as intended, there is little to no hazard associated with their use. Unfortunately, these are occasionally used in a manner that even at low powers could cause temporary or permanent damage to the eye. In addition, many cheap “low power” laser pointers are mislabeled and actually emit levels of laser radiation that can cause permanent eye damage in a time less than it takes to blink. There are also an increasing number of high power “laser pointers” available to the general public.

Contact the LSO if you have a laser pointer for which you wish to have the power level tested.

Laser pointers at Georgia Tech that are labeled as Class 3B or 4, or are tested to be Class 3B or 4 are considered to be under the jurisdiction of the program defined in this Laser Safety Policy Manual.

For more information on laser pointer safety, please refer to the document “Laser Pointer Safety” available at <https://ehs.gatech.edu/radiation/laser/>.



9. DISPOSAL OF A LASER

There are a variety of methods that a laser can be disposed. **In all cases, property surplus/disposal must be arranged through and approved by Georgia Tech Logistics (Surplus) - <http://www.procurement.gatech.edu/logistics>.**

9.1. Notification of disposal

9.1.1. The LS must notify the LSO of a laser disposal within 15 days of the action.

9.1.2. Per State of Georgia regulation 290-5-27-.04, the Georgia Department of Community Health must be notified within 30 days of the disposal of a laser. The LSO will communicate the disposal based on the notification from 9.1.1.

9.2. Disposal Methods

9.2.1. Return to the Manufacturer

9.2.1.1. Some manufacturers will accept the return of a laser as a credit towards the purchase of a new laser.

9.2.2. Send to Re-Sale Vendor

9.2.2.1. Vendors exist that specialize in the purchase, refurbishing and re-sale of used lasers.

9.2.3. Discard as Junk

The following items shall be addressed prior to the pickup of the equipment by Georgia Tech Logistics (Surplus)

9.2.3.1. Prior to discarding as junk, the laser should be rendered inoperable by removing means by which it can be electrically activated.

9.2.3.2. Efforts should be made to identify and arrange for the proper disposal of hazardous components from the laser. These might include organic dyes, mercury switches, oils, etc. Disposal of hazardous components must be arranged through the Georgia Tech EHS Hazardous Waste office.

9.2.3.3. Circuit boards and other components may be recyclable as E-waste.

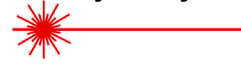
9.2.4. Public Auction or Transfer via Georgia Tech Logistics (Surplus)

9.2.4.1. Property made available by public auction or transfer to another organization for re-use is provided "As-Is" with no guarantees on functionality of any component. For dye lasers, excess laser dye must be removed prior to offering the laser to Georgia Tech Logistics (Surplus).



9.3. Lasers Built In-House and Sold Outside Georgia Tech

- 9.3.1. If a laser is built in-house and will then be sold to an entity outside of Georgia Tech, the Laser Supervisor is considered a manufacturer according to FDA regulations. In this case, the laser must be certified according to FDA laser product regulations and a Product Report submitted to FDA prior to the sale. Contact the LSO for guidance.



10. ACCIDENTS AND INJURIES

10.1. Incidents Requiring Emergency Attention

Immediately contact the Georgia Tech Police Department at 911 if calling from an on-campus landline phone or at 404-894-2500 if calling from a cell phone. Suspected or known exposure of the eye to laser radiation, whether or not there has been a noticeable change to an individual's vision, shall be treated as an emergency incident and the individual routed to a hospital emergency room. This will allow for the quickest referral to an ophthalmologist. Urgent care facilities typically do not have the means to perform a thorough medical eye exam.

Unless there is a life-threatening injury, transport to the emergency room is not required to be via EMS. Please do your best to have a Georgia Tech employee transport you to the emergency room in a Georgia Tech-owned vehicle.

Note: Any burn to the skin on the face shall also be treated as a suspected eye exposure.

10.2. Non-Emergency Injuries

Contact the LSO for guidance on where to seek medical care for non-emergency injuries. This guidance is different depending on whether the individual's status is employee, student, visitor, affiliate, etc. A non-emergency example is a minor burn to the skin anywhere other than on the face.

10.3. Medical Examinations

In addition to acute symptoms, consideration shall be given to the exposure wavelength, emission characteristics and exposure situation to assure appropriate medical referral. Appendix F of ANSI Z136.1-2014 provides recommended examination protocols by observed symptoms and the type of laser. For injury to the eye from lasers operating in the retinal hazard region, examinations shall be performed by an ophthalmologist.

Pre- and post-employment medical examinations for laser users are not required by either ANSI Z136.1-2014 or Z136.8-2012.

10.4. Accident and Injury Reporting

10.4.1. Georgia Tech Laser Injury Reporting

10.4.1.1. The LU shall report all incidents involving lasers to the LS as soon as possible. This includes eye and skin injuries, as well as chemical exposures, LGAC exposures, and electric shock accidents.

10.4.1.2. The LS shall report incidents involving their lasers to the LSO.



10.4.1.3. For injuries involving individuals employed by Georgia Tech, the LS shall file/make all reports and notifications detailed in the “Injury and Illness Reporting Guidelines” available at <http://ehs.gatech.edu/general/occupational-injury>.

10.4.2. State of Georgia Laser Injury Reporting

State of Georgia regulation 290-5-27-.03 requires Georgia Tech to report, in writing, any injury, regardless of severity or extent, sustained in the course of operating, handling, servicing, or manufacturing a laser within fifteen (15) days of detection of the injury. The LSO will submit this report.

10.5. Emergency Contact Information

A current emergency contact list shall be posted at the entry to the laser controlled area. Please use the EHS “Pink Card” for posting these contacts. The “Pink Card” is available at <http://ehs.gatech.edu/chemical/lab-signage>.

10.6. Accidental Eye and Skin Exposure

Accidental eye and skin exposure to laser radiation above the MPE resulting in injury can and does occur. Please refer to [Appendix I](#) for a listing of common causes of these accidental exposures.



APPENDIX A: Standards Incorporated by Reference

The ANSI Z136 series of laser safety standards are tentatively moving towards a structure wherein the ANSI Z136.1, Safe Use of Lasers standard is a horizontal standard with content that applies across all laser use. Individual vertical standards exist or are in development that provide details for specific uses. The most current version of the following standards are incorporated by reference and are currently the most applicable to laser use at Georgia Tech. Contact the LSO at 404-894-3605 for information on ordering a copy of any of these standards. The LSO maintains hard copies that can be borrowed on a short-term basis.

- ANSI Z136.1, Safe Use of Lasers
- ANSI Z136.4, Recommended Practice for Laser Safety Measurements for Hazard Evaluations
- ANSI Z136.6, Safe Use of Lasers Outdoors
- ANSI Z136.7, Testing and Labeling of Laser Protective Equipment
- ANSI Z136.8, Safe Use of Lasers in Research, Development, or Testing
- ANSI Z136.9, Safe Use of Lasers in Manufacturing Environments

Other current ANSI laser standards include

- ANSI Z136.2, Safe Use of Optical Fiber Communication Systems Utilizing Laser Diode and LED Sources
- ANSI Z136.3, Safe Use of Lasers in Health Care
- ANSI Z136.5, Safe Use of Lasers in Educational Institutions



APPENDIX B: Registration Forms

Form LS-1, Laser Supervisor Registration is available at
<https://ehs.gatech.edu/radiation/laser/documents>

Form LU-1, Laser User Registration is available at
<https://ehs.gatech.edu/radiation/laser/documents>

Form LR-1, Laser Registration is available at
<https://ehs.gatech.edu/radiation/laser/documents>



**APPENDIX C:
Standard Operating Procedure (SOP) Template**

The SOP Template is available at
<https://ehs.gatech.edu/radiation/laser/documents>



APPENDIX D: Typical Laser Classification

Typical Laser Classification – Continuous Wave (CW) Point Sources Lasers

Wavelength (nm)	Laser Type	Wavelength (nm)	Class 1 ^a (W)	Class 2 (W)	Class 3 ^b (W)	Class 4 (W)	
Ultraviolet 180 to 280	Neodymium: YAG (Quadrupled)	266	} $\leq 9.6 \times 10^{-9}$ for 8 hours	None	> Class 1 but ≤ 0.5	> 0.5	
	Argon	275					
Ultraviolet 315 to 400	Helium-Cadmium	325	} $\leq 3.2 \times 10^{-6}$	None	> Class 1 but ≤ 0.5	> 0.5	
	Argon	351, 363, 350.7,					
	Krypton	356.4					
Visible 400 to 700	Helium-Cadmium	441.6 only	$\leq 4 \times 10^{-5}$	} $> \text{Class 1 but } \leq 1 \times 10^{-3}$	> Class 2 but ≤ 0.5	> 0.5	
	Argon (Visible)	457	$\leq 5 \times 10^{-5}$				
		476	$\leq 1.3 \times 10^{-4}$				
		488	$\leq 2 \times 10^{-4}$				
		514					
	Krypton	530	} $\leq 2.2 \times 10^{-4}$				
	Neodymium: YAG (Doubled)	532					
	Helium-Neon	543	} $\leq 0.4 C_a \times 10^{-4}$				
	Dye	400 - 500					
	Helium-Selenium	460 - 500	} $\leq 4 \times 10^{-4}$				
	Dye	550 - 700					
	Helium-Neon	632	} $\leq 4 \times 10^{-4}$				
	InGaAlP	670					
Ti:Sapphire	350 - 500						
Krypton	647.1, 676.4						
Near Infrared 700 to 1400	GaAlAs	780	$\leq 5.6 \times 10^{-4}$	} None	> Class 1 but ≤ 0.5	> 0.5	
	GaAlAs	850	$\leq 7.7 \times 10^{-4}$				
	GaAs	905	$\leq 1.0 \times 10^{-3}$				
	Neodymium: YAG	1064	$\leq 1.9 \times 10^{-3}$				
	Helium-Neon	1080	$\leq 1.9 \times 10^{-3}$				
		1152	$\leq 2.1 \times 10^{-3}$				
	InGaAsP	1310	≤ 0.03				
	Nd:YAG	1319	≤ 0.025				
Far Infrared 1400 to $10^3 \mu\text{m}$	InGaAsP	1550	} $\leq 9.6 \times 10^{-3}$	None	> Class 1 but ≤ 0.5	> 0.5	
	Holmium	2100					
	Erbium	2940					
	Hydrogen Fluoride	2600 - 3000					
	Helium-Neon	3.390 μm only					
	Carbon Monoxide	5.000 - 5.500 μm					
	Carbon Dioxide	10.6 μm					
	Water Vapor	118 μm					} $\leq 9.5 \times 10^{-2}$
	Hydrogen Cyanide	337 μm					

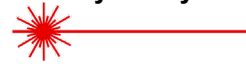
^a Assumes no mechanical or electrical design incorporated into laser system to prevent exposures from lasting up to $T_{\text{max}} = 8$ hours (one workday); otherwise the Class 1 AEL could be larger than tabulated.

^b See 3.3.3.1 for definition of Class 3R.


Typical Laser Classification – Single-Pulse Point Source Lasers

Wavelength (nm)	Laser Type	Wavelength (nm)	Pulse Duration (s)	Class 1 (J)	Class 3B (J)	Class 4 (J)
Ultraviolet						
180 to 400	Excimer (ArF)	193	20×10^{-9}	$\leq 2.4 \times 10^{-5}$	} > Class 1 but ≤ 0.125	} > 0.125
	Excimer (KrF)	248	20×10^{-9}	$\leq 2.4 \times 10^{-5}$		
	Neodymium: YAG (Q-switched)	266	20×10^{-9}	$\leq 2.4 \times 10^{-5}$		
	Excimer (XeCl)	308	20×10^{-9}	$\leq 5.3 \times 10^{-5}$		
	Nitrogen	337	20×10^{-9}	$\leq 5.3 \times 10^{-5}$		
	Excimer (XeF)	351	20×10^{-9}	$\leq 5.3 \times 10^{-5}$		
	Visible					
400 to 700	Rhodamine 6G (Dye Laser)	450-650	1×10^{-6}	} $\leq 7.7 \times 10^{-8}$	} > Class 1 but ≤ 0.03	} > 0.03
	Copper Vapor	510, 578	2.5×10^{-9}			
	Neodymium: YAG (Doubled) (Q-switched)	532	20×10^{-9}			
	Ruby (Q-switched)	694.3	20×10^{-9}			
	Ruby (Long Pulse)	694.3	1×10^{-3}			
Near Infrared						
700 to 1400	Ti: Sapphire	700-1000	6×10^{-6}	$\leq 8.4 \times 10^{-8}$	} > Class 1 but ≤ 0.033	} > 0.033 ^a
	Alexandrite	720-800	1×10^{-4}	$\leq 7.6 \times 10^{-7}$		
	Neodymium: YAG (Q-switched)	1064	20×10^{-9}	$\leq 7.7 \times 10^{-7}$		
Far Infrared						
1400 to $10^3 \mu\text{m}$	Erbium: Glass	1540	10×10^{-9}	$\leq 7.9 \times 10^{-3}$	} > Class 1 but ≤ 0.125	} > 0.125
	Co: Magnesium-Fluoride	1800-2500	80×10^{-6}	$\leq 7.9 \times 10^{-4}$		
	Holmium	2100	250×10^{-6}	$\leq 7.9 \times 10^{-4}$		
	Hydrogen Fluoride	2600-3000	0.4×10^{-6}	$\leq 1.1 \times 10^{-4}$		
	Erbium	2940	250×10^{-6}	$\leq 5.6 \times 10^{-4}$		
	Carbon Dioxide	10.6 μm	100×10^{-9}	$\leq 7.9 \times 10^{-5}$		
Carbon Dioxide	10.6 μm	1×10^{-3}	$\leq 7.9 \times 10^{-4}$			

^a Class 3B AEL varies from 0.033 J to 0.048 J corresponding to wavelengths that vary from 720 nm to 800 nm.



APPENDIX E: Summary of Control Measures for the Seven Laser Classes

The following three pages contain tables that summarize the engineering, administrative, and PPE control measures specified in ANSI Z136.1-2014, Safe Use of Lasers. There is a legend below each table describing how requirements (shall), recommendations (should), etc. are designated in the tables.


Table 10a. Control Measures for the Seven Laser Classes

Engineering Control Measures	Classification						
	1	1M	2	2M	3R	3B	4
Protective Housing (4.4.2.1)	X	X	X	X	X	X	X
Without Protective Housing (4.4.2.1.1)	LSO shall establish Alternative Controls						
Interlocks on Removable Protective Housings (4.4.2.1.3)	∇	∇	∇	∇	∇	X	X
Service Access Panel (4.4.2.1.4)	∇	∇	∇	∇	∇	X	X
Key Control (4.4.2.2)	—	—	—	—	—	•	•
Viewing Windows, Display Screens and Diffuse Display Screens (4.4.2.3)	Ensure viewing limited < MPE						
Collecting Optics (4.4.2.6)	X	X	X	X	X	X	X
Fully Open Beam Path (4.4.2.7.1)	—	—	—	—	—	X NHZ	X NHZ
Limited Open Beam Path (4.4.2.7.2)	—	—	—	—	—	X NHZ	X NHZ
Enclosed Beam Path (4.4.2.7.3)	Further controls not required if 4.4.2.1 and 4.4.2.1.3 fulfilled						
Area Warning Device (4.4.2.8)	—	—	—	—	—	•	X
Laser Radiation Emission Warning (4.4.2.9)	—	—	—	—	—	•	X
Class 4 Laser Controlled Area (4.4.2.10 and 4.4.3.5)	—	—	—	—	—	—	X
Entryway Controls (4.4.2.10.3)	—	—	—	—	—	—	X
Protective Barriers and Curtains (4.4.2.5)	—	—	—	—	—	•	•

LEGEND: X Shall
 • Should
 — No requirement
 ∇ Shall if enclosed Class 3B or Class 4
 NHZ Nominal Hazard Zone analysis required


Table 10b. Control Measures for the Seven Laser Classes (cont.)

Administrative (and Procedural) Control Measures	Classification						
	1	1M	2	2M	3R	3B	4
Standard Operating Procedures (4.4.3.1)	—	—	—	—	—	•	X
Output Emission Limitations (4.4.3.2)	—	—	—	—	LSO Determination		
Education and Training (4.4.3.3)	—	•	•	•	•	X	X
Authorized Personnel (4.4.3.4)					—	X	X
Indoor Laser Controlled Area (4.4.3.5)		•	—	•	—	X NHZ	X NHZ
Class 4 Laser Controlled Area (4.4.2.9 and 4.4.3.5)	—	—		—	—	—	X
Temporary Laser Controlled Area (4.4.3.5)	∇ MPE	∇ MPE	∇ MPE	∇ MPE	∇ MPE	—	—
Controlled Operation (4.4.3.5.2.1)	—	—	—	—	—	—	•
Outdoor Control Measures (4.4.3.6)	X	NHZ	X NHZ	NHZ	X NHZ	X NHZ	X NHZ
Laser in Navigable Airspace (4.4.3.6.2)	•	•	•	•	•	•	•
Alignment Procedures (4.4.3.8)	∇	X	X	X	X	X	X
Spectators (4.4.3.7)	—	•	—	•	—	•	X
Service Personnel (4.4.3.9)	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


Table 10c. Control Measures for the Seven Laser Classes (cont.)

Personal Protective Equipment PPE	Classification						
	1	1M	2	2M	3R	3B	4
Laser Eye Protection (4.4.4.1)	—	—				X	X
Skin Protection (4.4.4.3)						•	•
Protective Clothing (4.4.4.1 and 4.4.4.3.1)	—	—	—	—	—	•	•

LEGEND: X Shall
 • Should
 — No requirement

Table 10d. Control Measures for the Seven Laser Classes (cont.)

Control Measures: Special Considerations and Warning Signs	Classification						
	1	1M	2	2M	3R	3B	4
Laser Optical Fiber Transmission Systems (4.5.2)	MPE	MPE	MPE	MPE	MPE	X	X
Laser Robotic Automated Installations (4.5.3)						X NHZ	X NHZ
Laser Controlled Area Warning Signs (4.6)			—	—	—	X	X

LEGEND: X Shall
 — No requirement
 MPE Shall if MPE is exceeded
 NHZ Nominal Hazard Zone analysis required



APPENDIX F: Systems Containing Embedded Class 3B or 4 Lasers

An embedded laser is a laser designated Class 1, 2, or 3a (3R) for normal operation, but contains a Class 3B or Class 4 laser embedded in the system. Georgia Tech has many of these lasers which include, but are not limited to, laser engravers, cutters, and stereo lithography systems, actually contain an embedded Class 3B or 4 laser.

These embedded systems must have a designated LS. The LS must have completed the Georgia Tech laser safety training, registered via Form LS-1 and registered the laser with the LSO via Form LR-1. Aside from the LS, individuals that operate the embedded systems under normal operating conditions are not required to complete laser safety training or register as Laser Users.

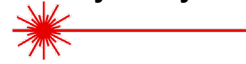
On-the-job training (OJT) shall be provided to all individuals engaging in normal operation of embedded lasers. This training should be documented by the LS.

During activities outside of normal operation, such as maintenance, repair, or other servicing, exposure to laser radiation above the MPE is possible. As such, laser hazard control measures that are not required for normal operation will be required during these activities. Any individual conducting activities outside of normal operation must complete the Georgia Tech laser safety training and register as a LU.

Other control measures may include, but are not necessarily limited to:

- Written Laser Standard Operating Procedure (SOP)
- Entryway warning signs
- Temporary use of laser barriers
- Use of laser protective eyewear

Contact the LSO at laser@ehs.gatech.edu for guidance prior to maintenance, repair, or other servicing activities.



APPENDIX G: ANSI Z-136.1-2014 Laser Warning Sign Examples

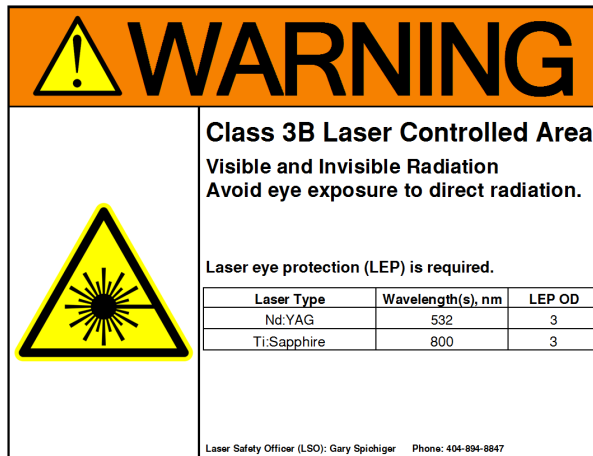
The laser warning sign format must be in compliance with the ANSI Z535 series of standards that include ANSI Z535.2, Environmental and Facility Safety Signs. Three examples are included in this appendix. Additional signs such as a “Notice” sign may be necessary for temporary laser controlled areas.

Along with the updated sign appearance, the signal word meanings have been revised and are to be used on the laser warning signs as follows, according to ANSI Z136.1-2014, 4.6.2.1.

“DANGER” – Indicates that serious injury or death will occur if necessary control measures are not implemented to mitigate the hazards within the laser controlled area. This signal word shall be restricted to those Class 4 lasers with high (e.g., multi-kilowatt) output power or pulse energies with exposed beams.

“WARNING” – Indicates an imminently hazardous situation that, if not avoided, could result in serious injury or death. This signal word shall be used on laser area warning signs associated with lasers whose output exceeds the applicable MPE for irradiance, including all Class 3B and most Class 4 lasers.

The LSO provides properly formatted warning signs for laser controlled areas at Georgia Tech.



WARNING

Class 3B Laser Controlled Area
Visible and Invisible Radiation
Avoid eye exposure to direct radiation.

Laser eye protection (LEP) is required.

Laser Type	Wavelength(s), nm	LEP OD
Nd:YAG	532	3
Ti:Sapphire	800	3

Laser Safety Officer (LSO): Gary Spichiger Phone: 404-894-8847

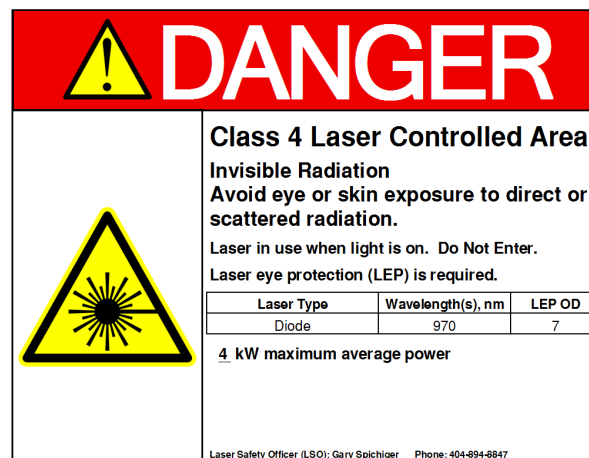


WARNING

Class 4 Laser Controlled Area
Avoid eye or skin exposure to direct or scattered radiation.
Laser in use when light is on.
Laser eye protection (LEP) is required.

Laser Type	Wavelength(s), nm	LEP OD
Nd:YAG	532	5

Laser Safety Officer (LSO): Gary Spichiger Phone: 404-894-8847



DANGER

Class 4 Laser Controlled Area
Invisible Radiation
Avoid eye or skin exposure to direct or scattered radiation.
Laser in use when light is on. Do Not Enter.
Laser eye protection (LEP) is required.

Laser Type	Wavelength(s), nm	LEP OD
Diode	970	7

4 kW maximum average power

Laser Safety Officer (LSO): Gary Spichiger Phone: 404-894-8847



APPENDIX H: Alignment Procedure Guidelines

Alignment shall only be done by a Laser Supervisor or Laser User that has completed laser safety training.

The following items should be implemented to improve safety during laser alignment. Additional guidance is found in the [Laser Standard Operating Procedure \(SOP\) Template](#).

- Ensure only individuals involved in the alignment are present.
- Use low-power visible lasers to simulate the path of higher power lasers that will be used in normal operation.
- If a low power laser cannot be used to simulate the beam path of a high power laser, operate the high power laser at the lowest possible power level needed to accomplish the alignment.
- If your fully protective laser eye protection makes it difficult to see the alignment beam, contact the LSO for assistance selecting alignment laser eye protection.
- Wear laser goggles instead of glasses when conducting alignment at a location with a lot of protruding objects that might push the glasses up when the person bends over to view the alignment spot. Make all efforts though to keep interfering objects out of the way.
- Use image converter viewers or phosphor cards when aligning invisible beams.
- Use a shutter or beam block to block high-power beams at the emission source except when actually needed for the alignment.
- Use a laser-rated beam block to terminate high-power beams down range of the optics being aligned.
- Use beams blocks and/or laser barriers in conditions where alignment beams could stray into areas with uninvolved individuals.
- Place beam blocks behind optics like turning mirrors to terminate beams that might miss the mirror during alignment.
- Locate and block all stray reflections before moving on to the next optical component or section.
- Be sure all beams and reflections are properly terminated before high-power operation.
- Post appropriate warning signs when an embedded laser is opened for alignment of its Class 3B or Class 4 laser.



APPENDIX I: Common Causes of Accidental Eye and Skin Exposure

- Unanticipated eye exposure during alignment
- Misaligned optics and upwardly directed beams
- Available laser eye protection not used
- Equipment malfunction
- Improper methods of handling high-voltage
- Intentional exposure of unprotected personnel
- Operators unfamiliar with laser equipment
- Lack of protection for non-beam hazards
- Improper restoration of equipment following service
- Laser eyewear protection worn not appropriate for laser in use
- Unanticipated eye/skin exposure during laser usage
- Inhalation of laser generated air contaminants and/or viewing laser generated plasmas
- Fires resulting from the ignition of materials
- Eye or skin injury of photochemical origin
- Failure to follow Standard Operating Procedures (SOPs)
- Introduction of foreign materials (pages of loose paper, paper clips, falling items or objects)
- Modification of the beam path