



## **LASER SAFETY POLICY MANUAL**



**ISSUED BY**

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

**July 1, 2010  
Revised  
January 31, 2012**



# 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:

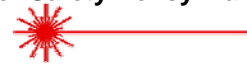
- assist the Laser Safety Committee with its responsibilities.
- have the authority to monitor and enforce the control of laser hazards at Georgia Tech.
- have the authority to suspend, restrict, or terminate the operation of a laser system if it is deemed that laser hazard controls are inadequate.

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.

APPROVED BY:

  
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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. 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.

To achieve this objective, Georgia Tech requires that all Class 3B and Class 4 lasers and laser systems be operated in accordance with the American National Standards Institute (ANSI) Z136.1-2007, "Safe Use of Lasers" and applicable federal and state regulations. As such, Georgia Tech adopts ANSI Z136.1-2007 as the basis of its laser safety program. This laser safety program applies to all Georgia Tech locations in the U.S., including mobile and temporary field locations.

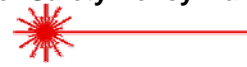
A Laser Safety Committee (LSC) has been established to oversee the laser safety program with the help of the Laser Safety Officer (LSO). While their main purpose is to educate and assist laser users in the safe use of lasers, the LSC and LSO have been given the authority to suspend, restrict, or terminate the operation of a laser system if it is deemed that laser hazard controls are inadequate. This authority is granted by the President of Georgia Tech.

All Class 3B and Class 4 laser operations at Georgia Tech shall be registered with the LSO and LSC. The LSO will register these systems with the Georgia Department of Community Health within 30 days of the acquisition of the laser (State of Georgia regulation 290-5-27.02). The LSO or designee will conduct a laser hazard assessment and it will be the responsibility of the Laser Supervisor (LS) to correct any safety deficiencies identified in the hazard assessment.

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

Exceptions to the ANSI standard will be considered on a case-by-case basis by the LSO and LSC. The LSO shall document and keep record of any policy decisions that are exceptions to the ANSI Z136.1-2007 standard.

If you need additional information or assistance, contact the Laser Safety Officer (LSO) at the Environmental Health and Safety (EHS) Office of Radiological Safety (the ORS) at 404-894-3605.



## **2. ACRONYMS/ABBREVIATIONS**

ANSI – American National Standards Institute

CW – Continuous Wave laser

EHS – Environmental Health & Safety

GT – Georgia Tech

LS – Laser Supervisor

LSC – Laser Safety Committee

LSO – Laser Safety Officer

LU – Laser User

MPE – Maximum Permissible Exposure

NHZ – Nominal Hazard Zone

OD – Optical Density

ORS – Office of Radiological Safety

SOP – Standard Operating Procedure



### **3. CONTROL MEASURES**

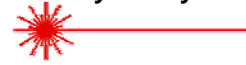
Control measures for Class 3B and 4 lasers are designed to reduce the possibility of eye and skin exposure to laser radiation in excess of the applicable Maximum Permissible Exposure (MPE) limit and other hazards associated with the laser systems.

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 engineering, administrative and procedural controls, and personal protective equipment. Engineering controls are always the preferred method to provide for safety in a laser laboratory. Administrative and procedural controls and personal protective equipment are to be used only where the engineering controls are inadequate or impractical to prevent access to laser radiation that may be or is in excess of the MPE. It is common that all types of control measures are required for a given laser system.

An important consideration when implementing control measures is to distinguish between operation, maintenance, and service. Control measures are to be based on the normal operation of the laser system. When either maintenance or service is performed, it is often necessary to implement control measures that are not needed under normal operation. This specifically applies to the maintenance or service of laser systems that are classified less than Class 3B for normal operation, but contain embedded Class 3B or 4 lasers. Please see Appendix F for information on these types of laser systems.

Appendix D provides a summary of the control measures from ANSI Z136.1 (2007) that specifically apply to Class 3B and Class 4 lasers. At the end of the appendix is a reproduction of ANSI Z136.1 (2007), Table 10 which summarizes control measures for all seven laser classes.



## 4. ORGANIZATION OF THE LASER SAFETY PROGRAM

This section was developed to inform Laser Supervisors and Laser Users of their roles and responsibilities to help provide a safe laser use environment at Georgia Tech. Also addressed are the roles and responsibilities of the Laser Safety Committee, Laser Safety Officer and Purchasing Department.

### 4.1. RESPONSIBILITIES OF LASER USERS

#### 4.1.1. Definition

A Laser User (LU) is an individual that has completed Georgia Tech's laser safety training, registered with the LSO, and uses/maintains/services Class 3B or 4 lasers under the direction of a Laser Supervisor.

#### 4.1.2. Authorization

An employee or student shall not operate a Class 3B or 4 laser system unless authorized to do so by the Laser Supervisor for that laser. Prior to use, the employee or student must submit the Form LU-1 Laser User Registration and complete the laser safety training provide by the ORS. A Laser User must submit the Form LU-1 for each Laser Supervisor for whom he/she is working.

#### 4.1.3. Compliance

All employees and students shall comply with the safety rules and procedures prescribed by the LS, LSO, and LSC (the LSC has final authority should conflict arise). Employees and students shall be familiar with all operating procedures applicable to their work. Intentional exposure of personnel to laser radiation is prohibited.

#### 4.1.4. Accident Reporting

All injuries and accidents involving lasers and laser systems shall be reported to the LS and the LSO. However, the treatment of injured personnel and the preservation of property shall be the first priority.

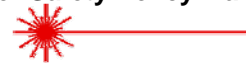
### 4.2. RESPONSIBILITIES OF THE LASER SUPERVISOR

#### 4.2.1. Definition

A Laser Supervisor (LS) is a Georgia Tech faculty or staff member that has primary responsibility for any use/maintenance/service of a given Class 3B or 4 laser.

#### 4.2.2. Prerequisite

The LS shall know the educational and training requirements, the potential laser hazards and associated control measures, and all OPERATING procedures pertaining to laser safety for lasers and laser systems under the LS's control. **The LS shall submit a Laser User Registration, Form LU-1 and a Laser Registration, Form LR-1 to the LSO.**



#### 4.2.3. Training

The LS shall ensure that all laser users under his/her control attend laser safety training offered by the ORS and shall ensure operational training is provided. The LS shall also attend the training offered by the ORS.

#### 4.2.4. Supervision of Laser Users

The LS shall determine which students and employees are authorized to operate a laser system under his/her control. The LS shall ensure that these individuals submit the Laser User Registration, Form LU-1.

#### 4.2.5. Accidents and Injuries

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 employee or student involved in the laser accident. 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.

#### 4.2.6. Acquisition of Class 3B and 4 lasers

The LS shall 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.).

#### 4.2.7. Operating Procedures

For Class 3B and 4 laser systems, the LS shall ensure standard operating procedures (SOPs) are developed and provided in order to prevent the operation of a laser if exposure to employees, students, visitors, or the general public could exceed the MPE.

The LS must train all Laser Users under his/her supervision on all laser SOPs at their laser facility.

SOPs shall also be necessary for alignment, maintenance and/or service, and emergency response. Appendix E provides a template for the development of a laser SOP.

Emergency procedures shall be posted in each laser facility.



### **4.3. RESPONSIBILITIES & SCOPE OF THE GEORGIA TECH LASER SAFETY COMMITTEE**

#### 4.3.1. Membership of Laser Safety Committee

4.3.1.1. The 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. The Laser Safety Officer (LSO) is an ex-officio member of the LSC.

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

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

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

#### 4.3.2. Scope

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

#### 4.3.3. Authority

The LSC and the LSO have the authority to suspend, restrict, and 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 President of Georgia Tech.

#### 4.3.4. Standards

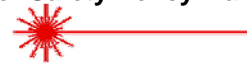
The committee will review all applicable new or revised laser safety standards.

#### 4.3.5. Responsibilities

4.3.5.1. The Committee shall meet quarterly and more often when situations arise that need attention.

4.3.5.2. Approvals by the Committee are signified by the receipt of a simple majority vote of approval by the eligible voting members of the Committee.

4.3.5.3. The Committee shall review and approve proposed laser procedures for the Georgia Tech campus. It shall also review and approve revisions to already existing procedures. Minor modifications to procedures and supporting forms which do not



change the original intent of the procedure may be approved by the Laser Safety Officer. Individuals on the Committee will serve as technical content experts providing consultation to the LSO.

- 4.3.5.4. The Committee shall review issues of concern whether they arise from injury, near misses, are the result of a laser hazard assessment, or are otherwise brought to the Committee's attention. The Committee shall take appropriate action to address the issue.
- 4.3.5.5. The Committee shall audit, on an annual basis, the laser records of the Office of Radiological Safety for compliance with internal rules, procedures and regulations.
- 4.3.5.6. Minutes of the Committee meetings, including any recommendations or occurrences, shall be recorded and distributed to all committee members. Committee minutes will be filed in the ORS office.
- 4.3.5.7. The Committee 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 Committee, the full membership will review the action and provide guidance.
- 4.3.5.8. The Committee shall review and approve all revisions to the Laser Safety Policy Manual.

#### **4.4. RESPONSIBILITIES AND AUTHORITY OF LASER SAFETY OFFICER**

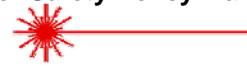
##### 4.4.1. Appointment

The LSO will work with the individual LS to ensure the safety standards of each laser laboratory are adequate. The LSO shall be appointed by the Assistant Vice President of Environmental Health & Safety and the Radiation Safety Officer and has the authority to monitor and enforce the control of laser hazards at Georgia Tech.

##### 4.4.2. Responsibilities

###### 4.4.2.1. Training Programs

Training shall be provided to each employee and student routinely operating a Class 3B or 4 laser or laser system. The level of training will be commensurate with the degree of potential laser hazards. A comprehensive laser safety training program is available from the ORS. Additional training programs are encouraged. The LSO shall be informed of the content of these additional programs.



#### 4.4.2.2. Registration

All Class 3b and 4 lasers must be registered with the Georgia Department of Community Health. The LSO will submit this registration to the State using information provided by the LS in the various application forms.

#### 4.4.2.3. Records

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

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

#### 4.4.2.4. Surveys and Inspections

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

The LSO will accompany regulatory agencies inspecting the laser facility.

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

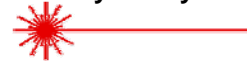
#### 4.4.2.5. Accidents and Injuries

Upon notification of a known or suspected laser-related accident or injury, the LSO shall investigate the accident or injury and take appropriate action. 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.

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 system within fifteen (15) days of detection of the injury.

### **4.5. RESPONSIBILITY OF PURCHASING DEPARTMENT**

The Georgia Tech Purchasing Department will inform, to the best of its ability, the LSO of all orders for lasers and laser systems. Notification should be in the form of a copy of the Purchasing Requisition. The LSO will contact the LS to determine if the appropriate laser safety controls are in place, and to provide guidance for any problems or deficiencies.



## 5. TRAINING

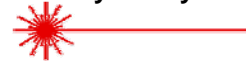
All Laser Supervisors and Laser Users must be trained in the safe use of lasers prior to beginning laser work. Laser Safety Training is offered by the ORS via an online program developed with Georgia Tech's Office of Organizational Development. Refresher training will be required periodically.

The training will include at least the following topics

- (a) Fundamentals of laser operation (physical principles, construction, etc.)
- (b) Bioeffects of laser radiation on the eye and skin
- (c) Significance of specular and diffuse reflections
- (d) Non-beam hazards of lasers
- (e) Laser and laser system classifications
- (f) Control measures
- (g) Overall responsibilities of management and employees
- (h) Medical surveillance 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 the laser safety training can be found at the ORS website <http://www.ors.gatech.edu/laser/>.



## 6. ACCIDENTS, INJURIES AND EMERGENCIES

All accidents involving lasers must be reported to the LS and LSO immediately. This includes chemical exposures, laser generated air contaminants, electrical shock accidents, as well as eye and skin injuries.

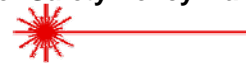
State of Georgia regulation 290-5-27-.03 requires Georgia Tech to report, in writing, any injury, regardless of severity or extent, sustained in the course of operating, handling, servicing, or manufacturing a laser system within fifteen (15) days of detection of the injury.

Any additional reporting requirements for worker's compensation, etc. shall also be addressed.

Medical examinations shall be performed as soon as practical (usually within 48 hours) when a suspected injury or adverse effect from a laser exposure occurs. In addition to the acute symptoms, consideration shall be given to the exposure wavelength, emission characteristics and exposure situation to assure appropriate medical referral. Appendix E of ANSI Z136.1-2007 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.

### **The major causes of laser accidents in the laboratory are:**

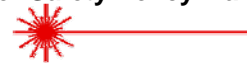
- Eye exposure during alignment
- Misaligned optics and upwardly directed beams
- Available eye protection not used
- Equipment malfunction
- Improper methods of handling high-voltage circuits
- Intentional exposure of unprotected personnel
- Operators unfamiliar with laser equipment
- Lack of protection from ancillary hazards
- Improper restoration of equipment following service
- Eyewear 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)



## **7. DISCONTINUATION OF USE OR DISPOSAL OF LASER SYSTEM**

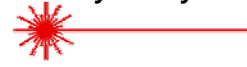
Per State of Georgia regulation 290-5-27-.04, the Georgia Department of Community Health must be notified within 30 days of the permanent discontinuation of laser operation or the permanent disposal of a laser system.

The Laser Supervisor must notify the LSO of either situation within 15 days of the action.



## **APPENDIX A: ANSI Z136.1 – 2007 Safe Use of Lasers**

**ANSI Z136.1-2007 Safe Use of Lasers is incorporated by reference. Contact the LSO at 404-894-3605 for information on ordering a copy of this standard or borrowing a copy on a short-term basis.**



## **APPENDIX B: Registration Forms**

- **Form LU-1 Laser User Registration**
- **Form LR-1 Laser Registration**

## Laser User Registration

New User     Existing User

**Instructions:** The registrant must complete laser safety training and submit this registration to the LSO prior to use of Class 3B or 4 lasers. A copy will be returned to the Laser Supervisor to be filed in the Laboratory Laser Safety Notebook. Both the Laser Supervisor and Laser User must sign. Please submit the form via Campus Mail to Gary Spichiger at mail code 0425 or via scan and e-mail to [gary.spichiger@ehs.gatech.edu](mailto:gary.spichiger@ehs.gatech.edu).

FOR ORS USE ONLY	
ORS #	
Training Date:	
Comments:	
LSO Signature:	
Date:	
Copy of Form LU-1 sent to LS by:	
	Date: _____

### 1. Laser User Information:

Last Name: \_\_\_\_\_ First Name: \_\_\_\_\_  
 Department: \_\_\_\_\_ GT ID #: \_\_\_\_\_  
 Office (Bldg. & Room): \_\_\_\_\_ Office Phone: \_\_\_\_\_  
 E-mail: \_\_\_\_\_ Home/Cell Phone: \_\_\_\_\_

### 2. Employment Status:

Faculty     Staff     Grad Student     Undergrad Student

### 3. In addition to a Laser User, I am registering as a Laser Supervisor

Yes     No

### 4. My principal duties as a Laser User will be:

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

### 5. Laser Laboratory Information:

Department: \_\_\_\_\_ Building: \_\_\_\_\_  
 Room: \_\_\_\_\_ Lab Phone: \_\_\_\_\_

**TO BE COMPLETED BY THE LASER USER REGISTRANT**

I have read and understand the Georgia Tech Laser Safety Policy Manual. I agree to adhere to this policy and assume responsibility for the safe use of lasers.

Laser User  
Registrant Signature: \_\_\_\_\_

Date: \_\_\_\_\_

Laser Supervisor  
Signature: \_\_\_\_\_

Date: \_\_\_\_\_

Laser Supervisor  
Printed Name: \_\_\_\_\_

**TO BE COMPLETED ONLY IF LASER SUPERVISOR REGISTRANT**

**LASER SUPERVISOR RESPONSIBILITIES**

1. I understand that as a Laser Supervisor I shall provide direct supervision of all Laser Users under my supervision during laser use until such time as I or my authorized designee are confident that they can handle the equipment safely and competently.
2. I understand that as a Laser Supervisor I shall provide training specific to the protocols in my lab.
3. I understand that as a Laser Supervisor I shall designate in writing to the Laser Safety Officer an alternate Laser Supervisor to provide oversight of my laser labs during a leave of absence greater than 60 days.
4. I understand that as a Laser Supervisor I shall notify the Laser Safety Officer in writing of my intention to terminate my Laser Supervisor status at least 30 days prior to the proposed termination.
5. I understand that as a Laser Supervisor I shall notify the Laser Safety Officer in writing of my intention to move my laser/laser lab at least 30 days prior to the proposed move.
6. I understand that as a Laser Supervisor I shall be responsible for all lasers on my inventory and I shall complete and sign my Annual Laser Inventory within two weeks of receiving the inventory.
7. I understand that as a Laser Supervisor I or my authorized designee shall review for correctness and sign all forms documenting requests for the acquisition, use or disposal of lasers in my lab(s).
8. I have read and understand the Georgia Tech Laser Safety Policy Manual. I agree to adhere to this policy and assume responsibility for the safe use of lasers.
9. I certify that the statements contained in this application are correct and complete to the best of my knowledge and belief.

**Laser Supervisor  
Registrant Signature:** \_\_\_\_\_

Date: \_\_\_\_\_

**Laser Supervisor  
Printed Name:** \_\_\_\_\_

## Laser Registration

**Instructions:** This form must be completed for each Class 3B or 4 laser or any lower class system containing an embedded Class 3B or 4 laser. Please submit the form via Campus Mail to Gary Spichiger at mail code 0425 or via scan and e-mail to [gary.spichiger@ehs.gatech.edu](mailto:gary.spichiger@ehs.gatech.edu).

For ORS Use Only	
ORS #:	
Entered Into Inventory by:	Registration Sent to State: <input type="checkbox"/>
Date:	Date:

<b>1. Laser Supervisor Information:</b>		
Last Name:		First Name:
Department:		E-mail:
<b>2. Laser Location:</b>		
Building:		Room:
<b>3. Type of Use:</b>		
<input type="checkbox"/> Alignment	<input type="checkbox"/> Experimental	<input type="checkbox"/> Research
<input type="checkbox"/> Demonstration	<input type="checkbox"/> Instructional	<input type="checkbox"/> Other
<b>4. Brief Description of Use (including how often used):</b>		
<b>5. Specifications of Laser System:</b>		
Laser Status: <input type="checkbox"/> In Use <input type="checkbox"/> In Storage	Manufacture Date:	
Manufacturer:	Model:	
S/N:	GT Inventory #:	Active Medium:
Class: <input type="checkbox"/> 3B <input type="checkbox"/> 4	Embedded in lower class system? <input type="checkbox"/> Yes <input type="checkbox"/> No	
Tunable Laser? <input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Scanning <input type="checkbox"/> Nonscanning	
Beam Diameter (mm):	Beam Divergence (mradian):	
Beam diameter & divergence measured at the <input type="checkbox"/> 1/e <input type="checkbox"/> 1/e <sup>2</sup> point.		
<input type="checkbox"/> Continuous Wave (CW)	Pulsed: ( <input type="checkbox"/> Single <input type="checkbox"/> Multiple)	
Wavelength(s) (nm):	Wavelength(s) (nm):	
Maximum Operating Power:	Minimum Pulse Duration:	
Typical Operating Power:	Maximum Pulse Frequency:	
Maximum Joules/Pulse:		
Typical Joules/Pulse:		

I certify that the information contained in this form is true and correct to the best of my knowledge and belief.

Laser Supervisor Signature: \_\_\_\_\_ Date: \_\_\_\_\_



## APPENDIX C: Laser Standard Operating Procedure (SOP) Template

### *Instructions:*

- Use this template to create a standard operating procedure for each Class 3B or Class 4 lasers.  
**NOTE:** *If your SOP(s) is already documented in another form and it includes the information indicated in this template, you may use your current document(s).*
- The Laser Supervisor shall train all Laser Users on this procedure and ensure it is followed each time the laser is used.
- Keep this SOP in a common location readily available to the Laser Supervisor and Laser User.
- This SOP should always be available for review upon request of the Laser Safety Officer.
- For specifications or operating conditions that frequently change, list anticipated ranges of specifications or operational settings.

This Laser Standard Operating Procedure has been written to aid with the safe use of the laser identified below. Laser Supervisors and Laser Users must follow this procedure for each laser use.

**LASER SAFETY CONTACTS**

<b>Laser Supervisor:</b>		<b>Phone:</b>		<b>Mobile:</b>	
<b>Primary Laser User:</b>		<b>Phone:</b>		<b>Mobile:</b>	
<b>Laser Safety Officer:</b>	Gary Spichiger	<b>Phone:</b>	404-894-3605	<b>Mobile:</b>	770-364-0824
<b>Medical Emergencies and Fire:</b>	Georgia Tech Police	<b>Phone:</b>	<b>911 or 404-894-2500</b>		

**Note:** If 911 is dialed from a cell phone, immediately mention Georgia Tech and you will be transferred to the Georgia Tech Police. Dialing 911 from a campus phone will directly connect you with the Georgia Tech Police.

**1. LASER DESCRIPTION**

<b>Laser Type:</b>		<b>Laser Location</b>	
<b>Manufacturer:</b>		<b>Department:</b>	
<b>Model:</b>		<b>Building:</b>	
<b>Class:</b>	<input type="checkbox"/> 3B <input type="checkbox"/> 4	<b>Room Number:</b>	

Emission	Wavelength(s) or Wavelength Range (nm)	Power (W)	Pulse Energy (J)	Pulse Duration (sec)	Pulse Frequency (Hz)	Eyewear Optical Density Required
<input type="checkbox"/> CW <input type="checkbox"/> Pulsed						

**Brief Description of Laser Use:**

**2. LASER SAFETY PROGRAM**

Please refer to the Georgia Tech Laser Safety Policy Manual available at <http://www.ors.gatech.edu/laser/> for the responsibilities of the Laser Supervisor and Laser User, a basic description of hazard control measures, warning sign requirements, laser safety training, and laser registration.

**3. SETUP, ALIGNMENT AND OPERATING PROCEDURES**

- A. Alignment/Setup  
(Include specific beam alignment/visualization aids to be used as well as PPE.)
  
- B. Start-up and Operation  
(List the basic sequential events that describe the complete operation, including when to don laser eyewear, etc. The procedures shall be written for the benefit of the Laser User who must read and understand them to perform the operation safely.)
  
- C. Shutdown  
(Describe normal and emergency shutdown procedures)

<b>Laser Hazard Control Measures</b>		
<b>Check if applicable</b>	<b>Control</b>	<b>Comments</b>
<input type="checkbox"/>	Entryway (door) interlocks	
<input type="checkbox"/>	Laser protective housing interlocks	
<input type="checkbox"/>	Emergency stop/panic button	
<input type="checkbox"/>	Master switch (operated by key or computer password)	
<input type="checkbox"/>	Beam stops/attenuators	
<input type="checkbox"/>	Beam path enclosure (e.g., light pipe)	
<input type="checkbox"/>	Protective barriers	
<input type="checkbox"/>	Warning signs	
<input type="checkbox"/>	Warning lights	
<input type="checkbox"/>	Other (specify):	

**4. PERSONAL PROTECTIVE EQUIPMENT**

**Laser Protective Eyewear**

WEAR THIS EYEWEAR		
Eyewear Manufacturer	Protected Wavelength(s)	Optical Density (OD)

**Other Protective Equipment**

Describe other protective equipment used. This might include the use of lab coats and/or sunscreen for UV laser use. Other items to describe here include laser rated barriers, curtains, window filters, etc.

**5. NON-BEAM HAZARDS OF THIS SYSTEM (CHECK ALL THAT APPLY)**

Check all non-beam hazards that apply and provide a brief description of the control measure(s) implemented to control the hazard.

- Chemical (dyes, solvents, etc.); attach applicable Material Safety Data Sheet (MSDS)
- Electrical (high voltage, large current, capacitors, etc.)
- Laser Generated Air Contaminants
- Compressed gases or cryogenic liquids
- Fire/ignition source
- Plasma/blue light exposure
- Other (specify):

**EMERGENCY PROCEDURES**  
(Post in the lab)

**In Case of Emergency**

1. Shut down laser (if it is safe to do so)
2. If there is a fire or medical emergency, call the Georgia Tech Police.
3. For non-emergency injuries:
  - a. Non-employee students should visit the Stamps Student Health Center at Georgia Tech.
  - b. Georgia Tech employees (Faculty/Staff/Student) should visit Concentra Urgent Care, 688 Spring Street, Atlanta, GA  
Phone – (401) 881-1155.
4. Call the Laser Supervisor and the Laser Safety Officer.

<b>Laser Supervisor:</b>		<b>Phone:</b>		<b>Mobile:</b>	
<b>Primary Laser User:</b>		<b>Phone:</b>		<b>Mobile:</b>	
<b>Laser Safety Officer:</b>	Gary Spichiger	<b>Phone::</b>	404-894-3605	<b>Mobile:</b>	770-364-0824
<b>Medical and Fire Emergencies:</b>	Georgia Tech Police	<b>Phone:</b>	<b>911 or 404-894-2500</b>		
<b>Note:</b> If 911 is dialed from a cell phone, immediately mention Georgia Tech and you will be transferred to the Georgia Tech Police. Dialing 911 from a campus phone will directly connect you with the Georgia Tech Police.					

**Laser User Review:**

I have read and understand this procedure and have been trained on implementing its contents.

<b>Name (Printed)</b>	<b>Signature</b>	<b>Date</b>
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		
13.		
14.		
15.		
16.		
17.		
18.		
19.		
20.		



## **APPENDIX D: Class 3B and Class 4 Laser Requirements Summary**

This appendix provides the Laser Supervisor a summary of the steps required for documenting the possession and use of Class 3B and Class 4 lasers and laser systems. The appendix also serves as a summary of the proper control measures for preventing eye or skin exposure in excess of the applicable Maximum Permissible Exposure (MPE) limit. The application of control measures will be specific to each laser setup and will be determined based on a laser hazard analysis.

### **Laser User Registration and Laser Registration**

- Complete Form LU-1 Laser User Registration and LR-1 Laser Registration and submit to the LSO [Required].
- Notify the Laser Safety Officer of planned acquisition prior to laser purchase (by e-mail is fine); indicate vendor, laser type, wavelength(s), maximum power and planned use location [Required].

### **Laser Safety Training**

- Complete laser safety training [Required].
- Ensure Laser Users you supervise complete laser safety training prior to operating a laser [Required].
- Provide your Laser Users with operational training for each laser they will use under your supervision [Required].

### **Control Measures**

The control measures listed in the following pages contain the ANSI Z136.1 (2007) section reference (in brackets) and an indication of whether the measure is a recommendation or a requirement. There may be some instances in which the Georgia Tech Laser Safety Committee has chosen to adopt an ANSI recommendation as a requirement.

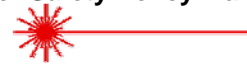
#### **General**

1. Maintain beam height at a level other than the normal position of the eye of a person standing or sitting [4.1 – Recommended 3B and 4]
2. Class 3B and 4 lasers shall be operated at all times under the direct supervision or control of an experienced, trained Laser User or Laser Supervisor. This supervision shall afford visual access to the entire laser controlled area during all conditions of operations so that laser emission can be terminated in the event of equipment malfunction or any other condition of unsafe use. [4.1.1.2 – Required 3B and 4]
3. Unattended laser operation is allowed only when control measures are in place to provide adequate protection and laser safety training to those who may enter the laser controlled area during times of unattended use. The area laser warning signs in place must include instructions regarding the hazards of entry into the space when no operator is present. [4.1.1.3 – Required 3B and 4]

#### **Engineering Controls**

##### *Protective Housings*

1. A protective housing shall be present and in good condition [4.3.1 – Required 3B and 4]
2. If the protective housing is user-created, appropriate control measures shall be instituted. [4.3.1.1 – Required]



#### *Service Access Panels*

1. Any service panel intended only for removal by service personnel shall be interlocked or removable only with special tool. A laser warning label shall be included on the service panel if it is removable with a special tool. [4.3.3 – Required 3B and 4]

#### *Master Switches*

1. The laser should have a master switch for beam termination or system shutoff that is either key operated or computer password accessible. [4.3.4 – Recommended 3B and 4]

#### *Viewing Windows, Display Screens and Collecting Optics*

1. Viewing windows and diffuse display screens shall be designed to maintain laser radiation below MPE at the viewing location [4.3.5.1 – Required]
2. Interlocks, filters and attenuators shall be used to keep laser radiation transmitted through collecting optics at or below the MPE. [4.3.5.2 – Required]
3. Collecting optics housings containing laser protective filters shall be labeled with the OD and wavelength from which the filter provides protection. [4.3.5.2 – Required]

#### *Beam Paths*

1. Control of the beam path shall be accomplished as described below. [4.3.6 – Required 3B and 4]
  - a. If the beam path is fully open a laser hazard evaluation shall be conducted [4.3.6.1 – Required 3B and 4]
  - b. If the exposed path of the beam is limited a laser hazard evaluation shall be conducted. [4.3.6.2 – Required 3B and 4]
  - c. If the beam path is fully enclosed, and the enclosure meets all requirements of a protective housing, then the laser will be considered 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. [4.3.6.3 – Required 3B and 4]

#### *Remote Interlock Connector*

1. A remote interlock connector should be provided on Class 3B lasers. [4.3.7 – Recommended 3B]
2. A remote interlock connector shall be provided on Class 4 lasers. [4.3.7 – Required 4]

#### *Beam Stop or Attenuator*

1. A permanently attached beam stop or attenuator should be provided on Class 3B lasers to prevent laser radiation in excess of the MPE when laser output is not needed, e.g., during laser warm-up. [4.3.8 – Recommended 3B]
  - a. If no laser warm-up time, then the power switch can be used instead of a beam stop or attenuator.
2. A permanently attached beam stop or attenuator shall be provided on Class 4 lasers to prevent laser radiation in excess of the MPE when laser output is not needed, e.g., during laser warm-up. [4.3.8 – Required for 4]
  - a. If no laser warm-up time, then the power switch can be used instead of a beam stop or attenuator.

#### *Laser Area Warning Signs and Activation Warnings*

1. The laser area must be posted with an appropriate warning sign [4.3.9.1 - Required 3B and 4]



2. Temporary laser controlled area must be posted with Notice sign [4.3.9.1 - Required 3B and 4]
3. Activation Warning System [4.3.9.4 - Recommended 3B, Required 4]
  - a. Audible warning during laser power supply charge; sounds unique to laser operation are acceptable [4.3.9.4.1]
  - b. Visible warning devices such as red light or lighted laser in use sign visible in the area [4.3.9.4.2]

*Indoor Laser Controlled Area*

1. A laser controlled area shall be established if a laser hazard analysis shows accessible radiation is Class 3B or 4 [4.3.10 - Required]
2. Class 3B indoor laser controlled areas shall: [4.3.10.1 – Required]
  - a. allow access only to personnel trained in laser safety,
  - b. be posted with an ANSI-formatted warning sign, and
  - c. have a well defined beam path.
3. Class 3B indoor laser controlled areas should: [4.3.10.1 - Recommended]
  - a. be under the direct supervision of a person trained in laser safety,
  - b. limit access to spectators and require approval for spectator access,
  - c. provide an appropriate beam stop for the laser,
  - d. have only diffusely reflecting material near the beam path,
  - e. provide laser protective eyewear,
  - f. have the exposed beam path above or below eye level of a seated or standing person,
  - g. have windows, doorways, etc. covered or restricted so that laser radiation is at or below the MPE, and
  - h. require that the laser be disabled (for example by removing and storing the key for the master switch) when not in use.
4. Class 4 indoor laser controlled areas shall: [4.3.10.2 – Required]
  - a. allow rapid entry and egress in emergency conditions,
  - b. allow only personnel trained in laser safety to enter the area
  - c. provide laser protective eyewear and any other necessary personal protective equipment,
  - d. require adherence to all administrative and procedural controls,
  - e. provide a clearly marked emergency stop switch to deactivate the laser or reduce the laser output to at or below the MPE,
  - f. provide entryway controls suitable for a Class 3B indoor laser controlled area AND shall incorporate one of the following additional controls:
    - i. Non-defeatable area or entryway interlocks shall be used to reduce laser radiation to at or below the MPE in the event of an unexpected entry,
    - ii. Defeatable area or entryway controls shall be used if non-defeatable interlocks will prevent the intended use of laser. Defeatable interlocks shall be used only if it is clear that the MPE will not be exceeded at the point of entry. All persons with access shall have completed laser safety training. Personal protective equipment (e.g., laser protective eyewear) shall be provided for all persons with access.



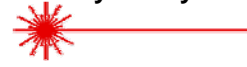
- iii. Procedural area or entryway safety controls (no interlocks) shall be used only when interlocks are not feasible. When procedural entryway controls are used:
  1. all personnel shall complete laser safety training,
  2. personal protective equipment shall be provided prior to or immediately upon entry,
  3. a barrier shall be used such that laser radiation will not exceed the MPE at the entryway, and
  4. an activation warning system shall be located at the entryway indicating that the laser is energized and operating at Class 4 levels.
5. Temporary laser controlled areas shall be used when panels or protective housings are removed, or when protective housing interlocks are overridden and the laser radiation exceeds the MPE. [4.3.12 – Required all laser classes]
  - a. An ANSI-formatted “NOTICE” sign shall be posted along with the applicable Class 3B or 4 ANSI-formatted warning sign.
6. Class 4 lasers should be controlled and monitored as far as possible from the emission portal of the laser. [4.3.13 – Recommended 4]
7. Equipment labels shall be present on each laser. Equipment labels shall include: [4.3.14 - Required all laser classes]
  - a. a warning logotype label on both the laser and the control if separated by more than 2 meters,
  - b. a protective housing label, and
  - c. a beam conduit label every 3 meters for long distance beam conduits.

#### **Administrative and Procedural Controls**

1. Standard operating procedures should be written and maintained for users of Class 3B lasers [4.4.1 - Recommended 3B]
2. Standard operating procedures shall be written and maintained for users of Class 4 lasers [4.4.1 – Required 4]
3. Laser safety training shall be completed by all Class 3B and 4 laser users. [4.4.3 - Required 3B and 4]
4. Class 3B and 4 lasers shall be operated only by authorized personnel. Authorized personnel are Laser Supervisors and Laser Users that have registered and completed laser safety training. [4.4.4 - Required 3B and 4]
5. Alignment standard operating procedures should be written for Class 3B laser setup and/or alignment. [4.4.5 - Recommended 3B]
6. Alignment standard operating procedures shall be written for Class 4 laser setup and/or alignment. [4.4.5 - Recommended 3B]

#### **Protective Equipment**

1. When other controls do not reduce laser radiation to at or below the MPE, protective equipment should be provided for Class 3B laser use. [4.6.1 - Recommended 3B]
2. When other controls do not reduce laser radiation to at or below the MPE, protective equipment shall be provided for Class 4 laser use. [4.6.1 – Required 4]



3. Laser protective eyewear and protective clothing shall be used for open beam UV lasers. [4.6.2.2 – Required 3B and 4]
4. Facility windows located within the NHZ shall be provided with appropriate barriers or filters to reduce the transmitted laser radiation to at or below the MPE. [4.6.3 – Required 3B and 4]
5. Laser protective barriers and curtains should be used inside the controlled area to prevent laser light in excess of the MPE from exiting the entryway. [4.6.4 – Recommended 3B and 4]
  - a. When laser protective barriers or curtains are used, they shall be selected to withstand direct and diffusely scattered beams and shall have a damage threshold for beam penetration for a specific exposure time.
  - b. Selection of the barrier shall take into account the factors of flammability and decomposition products of the barrier material following laser exposure.
6. All laser protective equipment shall be labeled [4.6.5 – Required Class 3B and 4] as follows.
  - a. Laser protective eyewear shall be labeled with the OD and wavelength(s) for which protection is afforded.
  - b. Laser protective windows that are purchased as other than an integral part of the laser shall be labeled with the OD and wavelength(s) for which protection is afforded.
  - c. Collecting optics housings containing laser protective filters shall be labeled with the OD and wavelength(s) for which protection is afforded.
  - d. Laser protective barriers that are purchased as other than an integral part of the laser shall be labeled with the barrier exposure time and beam conditions under which protection is afforded (e.g., the irradiance in W/cm<sup>2</sup>).
  - e. Laser protective viewports and films that are purchased as other than an integral part of the laser shall be labeled with the OD and wavelength(s) for which protection is afforded.
7. Skin protection shall be used with Class 3B and 4 ultraviolet lasers if chronic exposure to at or near the MPE for skin is expected.

### Area Warning Signs

1. Area warning signs shall be in the ANSI format in accordance with ANSI Z535, [4.7.1 – Required 3B and 4]
2. Class 3B and 4 laser warning signs shall use the signal word “DANGER”. [4.7.3.1- Required 3B and 4]
3. Temporary laser controlled areas shall have an additional sign with the signal word “NOTICE”. [4.7.3.3]
4. Warning signs shall include the following information: [4.7.4 – Required 3B and 4]
  - a. In the upper panel:
    - i. DANGER to the right of the safety alert symbol which is a white equilateral triangle with a red exclamation point.
  - b. In the lower panel:
    - ii. A red laser burst symbol with a tail extending to the right.
      1. Above the tail of the laser burst
        - a. Laser protective eyewear requirements
        - b. Visible or invisible laser radiation notification
        - c. Knock before entering
        - d. Do Not Enter When Light is On



- e. Restricted Area
  2. Below the tail of the laser burst
    - a. Type of laser
    - b. emitted wavelength
    - c. pulse duration
    - d. maximum output
  3. Class of the laser at the bottom right
5. Warning signs shall be located where best to warn onlookers. [4.7.4.3 – Required 3B and 4]

### Equipment Labels

1. Equipment labels shall conform to the following, the Federal Laser Performance Standard or the IEC 60825-1 (or latest revision). [4.7.5 – Required 3B and 4]
  - a. Class 3B laser equipment labels shall read “Laser Radiation – Avoid Direct Exposure to Beam” above the tail of the laser burst.
  - b. Class 4 laser equipment labels shall read “Laser Radiation – Avoid Eye or Skin Exposure to Direct or Scattered Radiation” above the tail of the sunburst.
  - c. For Class 3B and 4 laser equipment labels, the type of laser, wavelength, pulse duration (if applicable) and maximum output shall be included below the tail of the laser burst.
  - d. The class of the laser shall be listed in the bottom right portion of the equipment label.


**Table 10. Control Measures for the Seven Laser Classes**

Engineering Control Measures	Classification						
	1	1M	2	2M	3R	3B	4
Protective Housing (4.3.1)	X	X	X	X	X	X	X
Without Protective Housing (4.3.1.1)	LSO shall establish Alternative Controls						
Interlocks on Removable Protective Housings (4.3.2)	∇	∇	∇	∇	∇	X	X
Service Access Panel (4.3.3)	∇	∇	∇	∇	∇	X	X
Key Control (4.3.4)	—	—	—	—	—	•	X
Viewing Windows, Display Screens and Collecting Optics(4.3.5.1)	Assure viewing limited < MPE						
Collecting Optics (4.3.5.2)							
Fully Open Beam Path (4.3.6.1)	—	—	—	—	—	X NHZ	X NHZ
Limited Open Beam Path (4.3.6.2)	—	—	—	—	—	X NHZ	X NHZ
Enclosed Beam Path (4.3.6.3)	None is required if 4.3.1 and 4.3.2 fulfilled						
Remote Interlock Connector (4.3.7)	—	—	—	—	—	•	X
Beam Stop or Attenuator (4.3.8)	—	—	—	—	—	•	X
Activation Warning Systems (4.3.9.4)	—	—	—	—	—	•	X
Indoor Laser Controlled Area (4.3.10)	—	*	—	*	—	X NHZ	X NHZ
Class 3B Indoor Laser Controlled Area (4.3.10.1)	—	—	—	—	—	X	—
Class 4 Laser Controlled Area (4.3.10.2)	—	—	—	—	—	—	X
Outdoor Control Measures (4.3.11)	X	* NHZ	X NHZ	* NHZ	X NHZ	X NHZ	X NHZ
Laser in Navigable Airspace (4.3.11.2)	X	* NHZ	X NHZ	* NHZ	X NHZ	X NHZ	X NHZ
Temporary Laser Controlled Area (4.3.12)	∇ MPE	∇ MPE	∇ MPE	∇ MPE	∇ MPE	—	—
Controlled Operation (4.3.13)	—	—	—	—	—	—	•
Equipment Labels (4.3.14 and 4.7)	X	X	X	X	X	X	X
Laser Area Warning Signs and Activation Warnings (4.3.9)	—	—	—	—	•	X NHZ	X NHZ

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

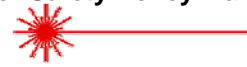
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**Table 10. Control Measures for the Seven Laser Classes (cont.)**

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

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

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## APPENDIX E:

### Typical Laser Classification – Continuous Wave (CW) Point Source Lasers

Wavelength (μm)	Laser Type	Wavelength (μm)	Class 1 * (W)	Class 2 (W)	Class 3 ** (W)	Class 4 (W)	
Ultraviolet 0.180 to 0.280	Neodymium: YAG (Quadrupled) Argon	0.266	} ≤ 9.6 × 10 <sup>-9</sup> for 8 hours	None	> Class 1 but ≤ 0.5	> 0.5	
		0.275					
Ultraviolet 0.315 to 0.400	Helium-Cadmium Argon Krypton	0.325	} ≤ 3.2 × 10 <sup>-6</sup>	None	> Class 1 but ≤ 0.5	> 0.5	
		0.351, 0.363, 0.3507, 0.3564					
Visible 0.400 to 0.700	Helium-Cadmium Argon (Visible)	0.4416 only	≤ 4 × 10 <sup>-5</sup>	} > Class 1 but ≤ 1 × 10 <sup>-3</sup>	> Class 2 but ≤ 0.5	> 0.5	
		0.457	≤ 5 × 10 <sup>-5</sup>				
		0.476	≤ 1 × 10 <sup>-4</sup>				
		0.488	≤ 2 × 10 <sup>-4</sup>				
	Krypton Neodymium: YAG (Doubled)	0.514	} ≤ 4 × 10 <sup>-4</sup>				
		0.530					
	0.532	} ≤ 0.4 C <sub>B</sub> × 10 <sup>-4</sup>					
	0.543						
	Dye	0.400 - 0.500	} ≤ 4 × 10 <sup>-4</sup>				
	Helium-Selenium	0.460 - 0.500					
Dye	0.550 - 0.700	} ≤ 4 × 10 <sup>-4</sup>					
Helium-Neon	0.632						
InGaAlP	0.670						
Ti:Sapphire	0.350 - 0.500						
Krypton	0.6471, 0.6764						
Near Infrared 0.700 to 1.400	GaAlAs	0.780	≤ 5.6 × 10 <sup>-4</sup>	} > Class 1 but ≤ 1 × 10 <sup>-3</sup>	> Class 2 but ≤ 0.5	> 0.5	
	GaAlAs	0.850	≤ 7.7 × 10 <sup>-4</sup>				
	GaAs	0.905	≤ 9.9 × 10 <sup>-4</sup>				
	Neodymium: YAG	1.064	≤ 1.9 × 10 <sup>-3</sup>				
	Helium-Neon	1.080	≤ 1.9 × 10 <sup>-3</sup>				
		1.152	≤ 2.1 × 10 <sup>-3</sup>				
	InGaAsP	1.310	≤ 1.5 × 10 <sup>-2</sup>				
Far Infrared 1.400 to 10 <sup>3</sup>	InGaAsP	1.550	} ≤ 9.6 × 10 <sup>-3</sup>	None	> Class 1 but ≤ 0.5	> 0.5	
		2.100					
		2.940					
		Hydrogen Fluoride					2.600 - 3.00
	Helium-Neon	3.390 only					
	Carbon Monoxide	5.000 - 5.500					
	Carbon Dioxide	10.6					
	Water Vapor	118					} ≤ 9.5 × 10 <sup>-2</sup>
	Hydrogen Cyanide	337					

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

\*\* See 3.3.3.1 for definition of Class 3R.

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### Typical Laser Classification – Single-Pulse Point Source Lasers

Wavelength ( $\mu\text{m}$ )	Laser Type	Wavelength ( $\mu\text{m}$ )	Pulse Duration (s)	Class 1 (J)	Class 3B (J)	Class 4 (J)
<b>Ultraviolet</b>						
0.180 to 0.400	Excimer (ArF)	0.193	$20 \times 10^{-9}$	$\leq 2.4 \times 10^{-5}$	$> \text{Class 1 but} \leq 0.125$	$> 0.125$
	Excimer (KrF)	0.248	$20 \times 10^{-9}$	$\leq 2.4 \times 10^{-5}$		
	Neodymium: YAG Q-switched (Quadrupled)	0.266	$20 \times 10^{-9}$	$\leq 2.4 \times 10^{-5}$		
	Excimer (XeCl)	0.308	$20 \times 10^{-9}$	$\leq 5.3 \times 10^{-5}$		
	Nitrogen	0.337	$20 \times 10^{-9}$	$\leq 5.3 \times 10^{-5}$		
	Excimer (XeF)	0.351	$20 \times 10^{-9}$	$\leq 5.3 \times 10^{-5}$		
	<b>Visible</b>					
0.400 to 0.700	Rhodamine 6G (Dye Laser)	0.450-0.650	$1 \times 10^{-6}$	$\leq 1.9 \times 10^{-7}$	$> \text{Class 1 but} \leq 0.03$	$> 0.03$
	Copper Vapor	0.510, 0.578	$2.5 \times 10^{-9}$			
	Neodymium: YAG (Doubled) (Q-switched)	0.532	$20 \times 10^{-9}$			
	Ruby (Q-switched)	0.6943	$20 \times 10^{-9}$			
	Ruby (Long Pulse)	0.6943	$1 \times 10^{-3}$			
<b>Near Infrared</b>						
0.700 to 1.4	Ti: Sapphire	0.700-1.000	$6 \times 10^{-6}$	$\leq 1.9 \times 10^{-7}$	$> \text{Class 1 but} \leq 0.033^*$	$> 0.033^{**}$
	Alexandrite	0.720-0.800	$1 \times 10^{-4}$	$\leq 7.6 \times 10^{-7}$		
	Neodymium: YAG (Q-switched)	1.064	$20 \times 10^{-9}$	$\leq 1.9 \times 10^{-6}$		
<b>Far Infrared</b>						
1.400 to $10^3$	Erbium: Glass	1.540	$10 \times 10^{-9}$	$\leq 7.9 \times 10^{-3}$	$> \text{Class 1 but} \leq 0.125$	$> 0.125$
	Co: Magnesium- Fluoride	1.8-2.5	$80 \times 10^{-6}$	$\leq 7.9 \times 10^{-4}$		
	Holmium	2.100	$250 \times 10^{-6}$	$\leq 7.9 \times 10^{-4}$		
	Hydrogen Fluoride	2.600-3.000	$0.4 \times 10^{-6}$	$\leq 1.1 \times 10^{-4}$		
	Erbium	2.940	$250 \times 10^{-6}$	$\leq 5.6 \times 10^{-4}$		
	Carbon Dioxide	10.6	$100 \times 10^{-9}$	$\leq 7.9 \times 10^{-5}$		
Carbon Dioxide	10.6	$1 \times 10^{-3}$	$\leq 7.9 \times 10^{-4}$			

\* Assuming that both eye and skin may be exposed, i.e., 1.0 mm beam (area of limiting aperture =  $7.9 \times 10^{-3} \text{ cm}^2$ ).

\*\* Class 3B AEL varies from 0.033 to 0.480 J corresponding to wavelengths that vary from 0.720 to 0.800  $\mu\text{m}$ .



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

Georgia Tech has a number of laser systems in use that are Class 1 lasers for normal operation. Many of these Class 1 lasers, such as laser engravers and stereo lithography systems actually contain an embedded Class 3B or 4 laser. 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. The control measures may include, but not necessarily be limited to:

- Entryway warning signs
- Temporary use of laser barriers
- Use of laser protective eyewear
- Laser safety training for individuals doing maintenance, repair, etc.

Contact the LSO for assistance.



## APPENDIX G: Frequently Asked Questions (FAQ)

### Why is there a laser safety program?

Many lasers are capable of causing eye injury to anyone who looks directly into the laser beam, or even at a specular (mirror-like) reflection of the beam. In addition, diffuse reflection of a high-power, Class 4 laser beam can produce permanent eye damage.

High-power laser beams can also burn exposed skin, ignite flammable materials, and cause the release of hazardous fumes, gases, and debris.

Other hazards associated with the equipment and optical apparatus required to produce the lasing action and control the beam can include high-voltage, high pressure, compressed gases, cryogenics, noise, ionizing and non-ionizing radiation, and toxic materials.

Despite the potential hazards, laser equipment can be operated safely if the proper procedures and necessary precautions are followed.

### Is my laser dangerous?

Locate the class label on the laser. All lasers sold in the US have one. This will tell you if it is class 1, 1M, 2, 2M, 3R, 3B or 4. Class 3a was also used prior to 2007. Dangers of a class 1, 1M, 2, 2M, 3a or 3R laser are much less significant than those of a class 3B or 4 laser. Even for these low power class lasers, however, direct exposure of the eye to the output beam can be dangerous. In addition, many of these lasers, regardless of class, have high-voltage power supplies that can be hazardous.

If you have a class 3B or 4 laser, yes, it is potentially dangerous, and you need to be careful.

I have a class 3B or 4 laser. What makes it dangerous to me?

Of foremost concern is the danger the laser poses to your eyesight. Irreparable damage to parts of your eye, and permanent partial or full loss of vision are possible. Lack of knowledge and training in laser safety is easily remedied and immensely valuable to helping you work safely.

High-power lasers usually have large power supplies designed to deliver large currents, often at high voltages. Accidents during troubleshooting can be fatal. Untrained personnel should stay out of the high voltage power supplies and away from capacitors.

There have been incidents where high-power lasers have ignited laboratory equipment, leading to fire and smoke damage to the laboratory.

There may be a risk of skin damage from direct exposure to the beam.



Excimer lasers make use of reactive gases requiring special safety precautions and procedures to prevent exposure.

How each of the above risks affects you depends on the type of laser, the wavelength, pulse energy (or power for a continuous wave laser), pulse duration (or exposure duration for a continuous wave laser), and the type of application.

### **I'm new to lasers. How do I figure out what to be concerned about in my lab?**

Ask your Laser Supervisor about it.

Ask your Laser Supervisor about the laser safety training provided through the Department of Environmental Health and Safety Office of Radiological Safety (the ORS). The ORS telephone number is 4-3605.

See the ORS website.

Read on to learn a little more, and where to obtain more details.

### **What is the danger to me?**

Depending on the wavelength of the laser light, your cornea, lens, or retina may absorb the light. When there's too much absorption, the cells are burned, leading to damage.

Effects on the skin are both photochemical and thermal depending on the wavelength of the laser light. Symptoms range from mild reddening (erythema) to blistering and charring. Also, there are possible carcinogenic effects.

Non-beam hazards include fumes, compressed gases, cryogenic materials, noise, electrical hazards, fire, explosion, and collateral radiation.

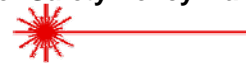
### **How do I know how much laser radiation is too much?**

Refer to the American National Standard for Safe Use of Lasers, ANSI Z136.1, for hazard analysis of several different laser types.

### **How can I avoid accidental exposure?**

Follow the Laser Standard Operating Procedure for your laboratory. A template is available in Appendix C of this manual. Contact the LSO if you have any questions.

Use correct approved laser safety goggles when appropriate. The lenses in goggles are for a specific wavelength range, and do not protect you outside of



this range. Even with goggles, consider direct exposure to a laser beam to be dangerous.

Question practices which appear unsafe to you. Are they necessary or outdated? Can the same function be performed in a manner which is less dangerous? Can the unsafe practices be replaced by some other diagnosis or measurement? Are work practices designed for expediency at the expense of safety?

### **Where can I get more laser safety information at Georgia Tech?**

Laser safety information is available in this program, at the ORS website and through the ORS.

### **Where can I find out about procedures at Georgia Tech?**

Procedures for the safe operation of a laser can be found in this document. In Chapter 2 and Appendix D discussion is made of features that should be designed into the laser and the laboratory, as well as information on procedural and administrative policies.

Procedures at Georgia Tech are based on the guidelines developed by American National Standards Institute (ANSI) in ANSI Z136.1 – Safe Use of Lasers. Contact the LSO for information on purchasing a copy of the current ANSI standard.