Policy
for

Laser Safety Policy

REVISION

Rev No.	DCN No.	Change Summary	Release Date	DCN Initiator	Document Owner
4	DCN0726	Added additional associated documents Edited sections 3, 8, 12, 14 and 17 Added section 8.5	10-28-11	T. Dobbs	R. Segura

Prior revision history, if applicable, is available from the Document Control Office.

1. PURPOSE AND SCOPE

1.1 The College of Nanoscale Science and Engineering (CNSE) laser safety policy is based on the recommendations of the American National Standards Institute Z136.1-2007 *Standard for the Safe Use of Lasers*, the New York State Department of Labor (NYSDOL) *Part 50 – Lasers* and the OSHA Technical Manual Section III Chapter 6.

1.2 The laser safety program's primary objective is to ensure that no laser radiation in excess of the Maximum Permissible Exposure (MPE) reaches the human eye or skin. This program is also intended to ensure adequate protection against laser related non-beam hazards.

2. DEFINITIONS

2.1 **ANSI Z136.1** – American National Standards Institute Z136.1-2007 (or latest version thereof) *Standard for the Safe Use of Lasers*

2.2 **CFR** – Code of Federal Regulations

2.3 **CW** – Continuous wave laser (laser operating with continuous output for more than 0.25 seconds)

2.4 **GCFI** – Ground Fault Interruption Circuit

2.5 **IR** – Infrared light (> 760 nm wavelength)

2.6 **LO** – Laser Operator

2.7 **LSO** – Laser Safety Officer

2.8 **EHS DEPARTMENT** –designated for day-to-day laser safety program operation.

2.9 **MPE** – Maximum Permissible Exposure, i.e. the laser radiation level to which a person can be exposed without hazardous effect or adverse biological changes in the eye or skin.

2.10 **MSDS** – Material Safety Data Sheet

2.11 **OSHA** – Occupational Safety and Health Administration

2.12 **PLU** – Principal Laser User, i.e. the individual directly responsible for the acquisition, use and maintenance of a particular laser/laser system. If no PLU has been formally identified for a particular laser/laser system, and inform the EHS Department of the designation.

2.13 **SOP** – Standard Operating Procedure

2.14 **UV** – Ultraviolet light (100 – 400 nm wavelength)

3. RESPONSIBILITIES

3.1 EHS Manager Responsibilities

3.1.1 Administer the overall Laser Safety Program.

3.1.2 Assume or designate the role of the Laser Safety Officer (LSO).

3.1.3 Maintain a current inventory of all classes of lasers.

3.1.4 Classify or verify classification of lasers and laser systems used on site.

3.1.5 Function as liaison between the principal laser users (PLUs).

3.1.6 Accompany outside inspectors/regulators on laser safety inspections.

3.1.7 Perform laser hazard analyses and audits.

3.1.8 Make recommendations to improve laser safety equipment and laser safety signage.

3.1.9 Restrict or terminate use of lasers that present an imminent danger or excessive hazard.

3.1.10 Ensure the availability of proper laser safety and make recommendations for selection of proper personnel protective equipment.

- Investigate laser accidents and near misses.
- Update laser safety policy and procedures as needed.
- Ensure adequate training is provided to laser users.
- Approve all laser Standard Operation Procedures (SOPs).

3.2 Principal Laser User (PLUs) Responsibilities

3.2.1 Complete a Laser Inventory Form, EHS-00016-F5 “Laser Inventory”, for each Class 3B or 4 Laser and send the form(s) to the EHS Department.

3.2.2 Ensure that SOPs are written for all Class 3B and 4 laser activities. These procedures, which must contain the name of and contact information for the PLU, will be approved by the EHS Department and posted near the laser. A copy shall be filed with the EHS Department.

3.2.3 Comply with the safety requirements outlined in this Laser Safety Policy.

3.2.4 Supervise the safe use of lasers in the laser environment.

3.2.5 Classify and label appropriately all lasers under his/her control.

3.2.6 Establish and maintain a current list of those personnel approved to operate specific types of Class 3B or 4 lasers under their supervision and provide a copy of the list to the EHS Department.

3.2.7 Complete the applicable Laser Safety course at the interval specified in this policy.

3.2.8 Immediately notify EHS in the event of a suspected overexposure to the output beam from a Class 3B or 4 laser.

3.3 **Laser Operator Responsibilities**:

3.3.1 Complete the applicable Laser Safety course and baseline ocular exam, before operating a Class 3B or 4 laser.

3.3.2 Use lasers safely.

3.3.3 Comply with established Laser Safety Policy, SOPs and other procedural requirements.

3.3.4 Promptly report to the PLU any malfunctions, problems, accidents, or injuries, which may have an impact on safety.

4. ASSOCIATED DOCUMENTS

EHS-00048-F1 – Requirements for Class 3B and 4 Lasers

EHS-00016-F5 – Laser Inventory

5. LASER CLASSIFICATION

All lasers and laser systems in the U.S. are categorized into one of several hazard classes. The laser classification scheme is based on the laser's capability to injure personnel.

Corresponding labels affixed to the laser or laser system shall be used to positively identify the laser classification. These laser classifications are detailed in ANSI Z136.1, ANSI Z136.3, and the Federal Laser Products Performance Standard, 21 CFR 1040.10 and 1040.11. The manufacturer

provides the classification for most lasers. For custom-built and modified lasers, the EHS Department can assist with classification.

5.1 Class 1 Lasers and Laser Systems

5.1.1 Do not emit harmful levels of radiation during normal operation.

5.1.2 Also includes higher class lasers completely enclosed and interlocked to prevent beam access, allowing a Class 1 laser system designation; any time the higher class laser is accessible (e.g. during alignment or servicing), the higher laser class controls must be observed.

5.1.3 Can be used without restriction in the manner intended by the manufacturer and without special operator training or qualification.

5.2 Class 1M Lasers and Laser Systems

5.2.1 Do not emit harmful levels of radiation during normal operation unless the beam is viewed with optical aids such as an eye-loupe, microscope or telescope.

5.2.2 Can be used without restriction but must have control measures to prevent hazardous optically aided viewing.

5.3 Class 2 Lasers and Laser Systems

5.3.1 Emits accessible laser light in the visible wavelength region.

5.3.2 Capable of creating eye damage through chronic exposure.

5.3.3 In general, the human eye will blink within 0.25 second when exposed to Class 2 laser light; this blink reflex provides adequate protection.

5.3.4 Can be used without restriction in the manner intended by the manufacturer and without special operator training or qualification.

5.4 Class 2M Lasers and Laser Systems

5.4.1 Emits accessible laser light in the visible wavelength region.

5.4.2 Capable of creating eye damage through chronic exposure.

5.4.3 In general, the human eye will blink within 0.25 second when exposed to Class 2 laser light; this blink reflex provides adequate protection. However, class 2M laser can be hazardous if viewed with optical aids.

5.4.4 Can be used without restriction in the manner intended by the manufacturer and without special operator training or qualification, but must have control measures to prevent hazardous optically aided viewing.

5.5 Class 3R Lasers and Laser Systems

5.5.1 Normally not hazardous when viewed momentarily with the unaided eye, but may pose severe eye hazards when viewed through collecting optics (e.g., microscopes and binoculars).

5.5.2 Include lasers and laser systems which have power levels 1-5 milliwatt (mW).

5.5.3 Same controls as Class 1 and Class 2 lasers for normal operations; if viewed through optical instruments (e.g., binoculars, telescopes, or microscopes), contact the EHS Department for a hazard review.

5.6 Class 3B Lasers and Laser Systems (Ultra Violet and near Infra Red)

5.6.1 Will cause injury upon direct viewing of the beam and specular reflections.

5.6.2 Power output 5-500 mW for CW or less than 0.03 joule (J) for a pulsed system (i.e. pulse width less than 0.25 second).

5.6.3 Must implement specific control measures covered in this document.

5.7 Class 4 Lasers and Laser Systems

5.7.1 Includes all laser systems with power levels greater than 500 mW CW or greater than 0.03 J for a pulsed system.

5.7.2 Pose eye hazards, skin hazards, and fire hazards. Viewing the beam or specular reflections or exposure to diffuse reflections can cause eye and skin injuries.

5.7.3 All control measures explained in this document must be implemented.

5.8 Embedded Lasers

5.8.1 Lasers are often embedded in laser products or systems with a lower hazard class. When the laser system is used as intended, the controls for the system's class apply. When the system is opened (e.g. for service or alignment) and the embedded laser beam is accessible, a temporary control area must be established. The controls for the temporary control area must be based on the classification of the embedded laser. The user and EHS Department must determine adequate controls. Confirmation of a system classification is the responsibility of the EHS Department, and therefore necessitates registering the system. An abbreviated SOP may be required, as in the case of such commercially available enclosed laser systems as a laser scanning confocal microscope.

6. LASER ACQUISITION, TRANSFER, AND DISPOSAL

6.1 Notify the EHS Department of any decision to purchase, fabricate, or otherwise acquire a Class 3B or Class 4 laser. The EHS Department will review with the user the hazards of the proposed operation and make recommendations regarding the specific safety requirements that pertain to the proposed use, including requirements for SOPs, laser control areas, training, and personnel protective equipment (See Requirements for Class 3B and 4 lasers EHS-00048-F1). The user shall also complete the requirements set forth in the New Equipment and Process Change Management EHS-00016 and submit to EHS for approval prior to purchase.

6.2 Also notify the EHS Department of any class 3B or 4 laser or laser system relocated, transferred to another PLU or institution, or sent offsite as surplus equipment.

7. MAXIMUM PERMISSIBLE EXPOSURE LIMITS

7.1 The Nominal Hazard Zone (NHZ) describes the space within which the level of direct, reflected, or scattered radiation during normal operation exceeds the MPE. The NHZ associated with open-beam Class 3B and Class 4 laser installations can be useful in assessing area hazards and implementing controls.

7.2 It is often necessary in some applications where open beams are required to define the area where the possibility exists for potentially hazardous exposure. This is done by determining the NHZ. Consequently, persons outside the NHZ boundary would be exposed below the MPE level and are considered to be in a non-hazardous location.

7.3 The NHZ boundary may be defined, for example, by direct beams (intrabeam) and diffusely scattered laser beams, as well as beams transmitted from fiber optics and/or through lens arrays. The NHZ perimeter is the envelope of MPE exposure levels from any specific laser installation geometry. See Appendix A for the NHZ Distance Values for Various Lasers

7.4 The purpose of an NHZ evaluation is to define that space where control measures are required. This is an important factor since, as the scope of laser uses has expanded, controlling lasers by total enclosure in a protective housing or interlocked room is limiting and, in many instances, an expensive overreaction to the real hazards. The following factors are required in NHZ computations:

- Laser power or energy output;

- Beam diameter;
- Beam divergence;
- Pulse repetition frequency (prf) (if applicable);
- Wavelength;
- Beam optics and beam path; and
- Maximum anticipated exposure duration.

8. LASER HAZARD CONTROL MEASURES

8.1 General Considerations

8.1.1 Control measures shall be devised to reduce the possibility of exposure of the eye and skin to hazardous levels of laser radiation and other hazards associated with laser devices during operation and maintenance.

8.1.2 The EHS Manager shall have the authority to monitor and enforce the control of laser hazards and effect knowledgeable evaluation and control of laser hazards and surveillance of the appropriate control measures.

8.2 Controls for Class 1, 1M, 2, 2M and 3R Lasers.

8.2.1 Class 1, 1M, 2, 2M and 3R laser beams may not be intentionally directed at a law enforcement officer or the head or face of another person, except for:

- Law enforcement purposes by police, or
- Medical use by authorized medical personnel.

8.2.2 Class 1M, 2M and 3R laser beams must not be viewed with collecting optics (e.g. microscopes) unless the optical system is specifically designed and constructed to prevent eye exposure exceeding the applicable MPE.

8.2.3 If a Class 1M, 2, 2M or 3R is not operated at all times under direct supervision of the operator the laser or laser system shall have a clearly visible and appropriate precautionary sign that conforms to ANSI Z136.1 guidelines.

8.2.4 Only Class 1 lasers or laser systems can be used unattended without additional control measures.

8.2.5 Otherwise, no other specific laser safety requirements apply to Class 1, 1M, 2, 2M and 3R lasers.

8.3 Controls for Class 3B and Class 4 Lasers

8.3.1 Class 3B and Class 4 lasers may be operated only in designated laser control areas or in other laser control areas approved by the EHS Department. The purpose of laser control areas is to confine laser hazards to well-defined spaces that are under the control of the laser user, thereby preventing injury to those visiting and working near the control area. All personnel authorized to enter a Class 3B or Class 4 laser controlled area shall be appropriately trained, and must follow all applicable administrative and operational controls.

8.3.2 Posting

- The area must be posted with appropriate warning signs that indicate the nature of the hazard.
- The wording on the signs will be specified by the EHS Department and conform to the ANSI Z136.1 guidelines. Such signs shall be posted at all entrances to the laser control area during the time a procedure utilizing the active beam is in progress, and shall be removed when the procedure is completed.

8.3.3 Authorization

- Only personnel who have been authorized by the PLU may operate the laser. Personnel may be authorized upon completing the applicable laser safety training. The PLU may stipulate additional authorization requirements.

8.3.4 Beam Stop

- All laser beams, other than those applied to tissue for surgical or therapeutic purposes, must be terminated at the end of their useful paths by a material that is non-reflective and (for class 4 lasers) fire resistant.

8.3.5 Eye Protection

- Lasers should be mounted so that the beam path is not at eye level for standing or seated personnel. Laser protective eyewear of adequate optical density and threshold limit for the beams under manipulation must be provided and worn at any point where laser exposure could exceed the MPE. Procedures and practices must ensure that optical systems and power levels are not adjusted upstream during critical open beam operations, such as beam alignment.

- The need for laser eye protection must be balanced by the need for adequate visible light transmission. It is the responsibility of the PLU to obtain appropriate laser protective eyewear.

- For assistance in selecting laser eye protection, contact the EHS Department. The EHS Department can assist the user in determining the proper parameters of such eyewear, and can provide contact numbers for vendors. Laser eye protection should be inspected periodically to ensure that it is in good condition. See Appendix B - Attenuation of Laser Safety Eyewear.

- All eye protection shall be inspected once every 6 months to ensure it meets the requirements for the lasers in use and it has no damage or defects.

8.3.6 Light Containment

- Laser light levels in excess of the MPE must not pass the boundaries of the control area. All windows, doorways, open portals, and other openings through which light might escape from a laser control area must be covered or shielded in such a manner as to preclude the transmission of laser light. Special rules apply for outdoor use and laser control areas that do not provide complete containment. Contact the EHS Department for details. Where feasible, the laser user is required to keep all laser beams within the operating field, on the optical table or within the experimental envelope at all times. To maintain this control it is essential to be aware of all beams, including stray beams and/or reflections, and to terminate them with beam stops at the end of their useful paths. When a beam traverses to other tables or across aisles, the beam must be enclosed or the access to the aisle must be blocked to prevent personnel from exposure to the beam.

8.3.7 Unattended Laser Operation

- Class 3B and Class 4 lasers and laser systems shall be operated at all times under direct supervision of a trained operator. The operator shall monitor conditions for safe use and terminate use of equipment is the event of malfunction or unsafe conditions.

- If Class 3B and Class 4 lasers and laser systems are not operated at all times by an experienced and trained operator, the radiation levels to which access can be gained shall be limited by control measures so that unprotected persons are not exposed to levels that exceed the MPE limits.

- The unattended use of Class 3B and Class 4 lasers and laser systems shall only be permitted once appropriate control measures are implemented to provide adequate protections to those who may enter the laser controlled area and prevent unauthorized access.

- The LSO and/ or EHS must approve the unattended use of Class 3B and Class 4 lasers and laser systems.

8.4 Additional Controls for Class 4 Lasers

Only appropriately trained personnel may enter a Class 4 laser controlled area during the time a procedure utilizing the active beam is in progress. All personnel within the control area must be provided with appropriate protective equipment and are required to follow all applicable administrative controls. Class 4 laser control areas must meet all of the requirements that apply to Class 3B control areas and also the following requirements:

8.4.1 Rapid Egress and Emergency Access

There must be provisions for rapid egress from a laser control area under all normal and emergency conditions. Any control area interlock system must not interfere with emergency egress. In addition, access control measures must not interfere with the ability of emergency response personnel (fire, paramedical, police) to enter the laser control area in the event operating personnel become injured or incapacitated.

8.4.2 Laser Activation Warning Systems and Entry Controls

Procedural area or entryway controls must be in place to prevent inadvertent entry into a laser control area, or inadvertent exposure to the active laser beam. These measures should include:

(a) A visible sign or audible warning sign or signal must be at the entrance to the control area to indicate when the laser is energized and operating;

(b) Provision of personnel with proper training and laser protective eyewear; and

(c) Doors or blocking curtains/barriers that attenuate the laser beam to below the MPE at the entranceway. The results of a formal hazard evaluation by the EHS Department may require more rigorous entryway controls to be put into place, depending upon the level of the hazard. These may include door interlocks or other entryway safety controls such as door mats with sensors that are designed to be interlocked to the laser power supply or laser shutter.

Locking entryway doors as a means of access control is not acceptable, because it is contrary to the principle of permitting rapid egress or emergency access,

8.4.3 Key Switches

For those laser systems equipped with a key switch to prevent unauthorized use, the key must not be left in the switch when the laser system is unattended.

8.5 Violation of Control Measures

8.5.1 Any person who is seen to purposely violate or disregard laser safety control measures will immediately loose access to all laser areas.

8.5.2 Any person who purposely violates or disregards this policy must re-take the laser safety course and prove competency to the LSO before access to the laser area is granted.

9. PERSONAL PROTECTION

Each person who possesses a laser shall instruct and advise every individual employed in or lawfully frequenting a laser radiation area in regard to the following:

- The presence of a laser in such area.
- The potential hazards associated with the use of the laser and the precautions and procedures necessary to minimize exposure to radiation from the laser.

- The applicable sections of this procedure that identify the protection of such individual from exposure to radiation from the laser.

9.1 Personal Protective Devices

9.1.1 Approved Safety Eyewear

- Approved safety eyewear, as required by this procedure, shall be provided by the owner or employer and shall be used by the individuals working with or operating any unshielded laser and by other individuals lawfully frequenting the laser radiation area who may be exposed to laser radiation under circumstances where the conditions of laser use can lead to accidental exposure to radiation above the maximum permissible exposure (MPE) limits listed in this procedure. Such safety eyewear shall meet the following specifications:

- The optical density of such approved safety eyewear shall reduce the external laser radiation to the cornea of the eye to safe levels as listed in Appendix B of this procedure.

- Such safety eyewear shall be designed and tested to ensure that the eyewear retains its protective properties during use.

- Such safety eyewear shall be legibly labeled with the optical density of the lens and the wave length at which it was measured.

- Any individual requiring prescription lenses in the normal performance of his work shall be provided with approved prescription eye protection or with approved safety eyewear designed to fit over his regular prescription lenses.

9.2 Other Personal Protective Devices

Other personal protective devices such as protective gloves, clothing and shields shall be provided by the owner or employer and used by individuals as determined by the EHS Department.

10. DESIGNATION OF LASERS

10.1 Every laser not otherwise exempt shall have a label so attached as to be clearly visible and such label shall contain the following information:

- The laser radiation symbol in red.

- The words "CAUTION" or "DANGER" and "LASER" in black letters.

a) In all areas where class 3B and class 4 lasers operate unattended “DANGER” must be used.

- The wave length or lengths of the emitted laser radiation.
- The maximum output power or energy density or densities of the emitted laser radiation.
- The divergence of the emitted laser radiation in its lowest order transverse mode.

10.2 Such required information shall be legibly stamped, etched or otherwise permanently marked on a yellow or white label with letters and numbers not less than three millimeters (one- eighth inch) in height where practicable.

10.3 Exceptions:

- If such labeling of individual lasers is impractical because of laser size or location, such lasers shall be appropriately labeled in an alternative manner.
- The label on any laser used exclusively in research and development need not specify numerically the wave length, maximum output power or energy density or the divergence where such parameters may be unknown or difficult to obtain. However, such labels shall contain the laser radiation-symbol and other wording required by section 7.1.

11. DESIGNATION OF LASER RADIATION AREA

11.1 Laser Radiation Symbol: The laser radiation symbol shall be used to designate lasers and laser radiation areas. The symbol shall be in red and the background area shall be yellow or white.

11.2 Laser Radiation Area: Except as below provided, each person who possesses a laser shall post conspicuously at the entrance to and inside of each laser radiation area a sign constructed of durable material bearing the laser radiation symbol and the words "CAUTION" or "DANGER" and "LASER RADIATION AREA". Such words shall be in black letters at least one inch in height.

11.2.1 Exception: No such area need be posted with any sign or equipped with any required control device solely because of the presence therein of any laser for any period of not more than eight hours, provided, however, that during such period the laser safety officer or a designated individual is constantly in attendance and such safety officer or designated individual

shall take all precautions necessary to prevent any individual from receiving any exposure to laser radiation that exceeds the applicable exposure limits and from receiving any other injury from any other hazard associated with the operation of any laser. Such area shall be subject to the control of the owner of such laser

11.3 Temporary Laser Control Areas

Temporary laser control areas can be created for the servicing and alignment of embedded lasers, enclosed lasers, and in special cases where permanent laser control areas cannot be provided. They are subject to the normal SOP approval process.

11.4 Special Requirements for Invisible Laser Beams

Since IR and UV laser beams are not within the boundaries of normal human vision, they possess a higher hazard potential than visible light lasers. Because of the invisible nature of the optical radiation, the use of laser eyewear that will protect against worst-case exposures is required at all times.

11.5 Infrared Lasers

11.5.1 Infrared laser beams (> 700 nm), other than those applied to tissue for surgical or therapeutic purposes, must be terminated by a highly absorbent, non-specular backstop. Note that many surfaces that appear dull are excellent IR reflectors and would not be suitable for this purpose.

11.5.2 Class 4 IR laser beam terminators must be made of a fire-retardant material, or of a material which has been treated to be fire-retardant.

11.6 Ultraviolet Lasers

UV radiation causes photochemical reaction in the eyes and the skin, as well as in materials that are found in laboratories. The latter may cause hazardous by-products such as ozone and skin-sensitizing agents. The direct beam and scattered radiation should be shielded to the practical maximum extent to avoid such problems. The use of long-sleeved coats, gloves, and face protectors is recommended. Some medications, including tetracycline, doxycycline, tricyclic antidepressants, and methotrexate, can increase a person’s risk to UV radiation. Contact the EHS Department for more information about this subject.

11.7 Substitution of Alternate Control Measures

Upon documented review by the EHS Department, the engineering control measures recommended by ANSI Z136.1 for Class 3B and Class 4 lasers or laser systems may be replaced by administrative or other alternate

engineering controls that provide equivalent protection. Approvals of these controls are subject to the same review procedure as described in this document.

12. LASER SAFETY TRAINING

12.1 Initial Training

All employees who use Class 3B or Class 4 lasers must complete the appropriate Laser Safety course.

12.2 Visitors

Guests of CNSE requesting to use or observe Class 3B or Class 4 lasers must contact the EHS Department regarding the training requirement for temporary personnel. New employees and guests may use lasers under the direct supervision of a PLU until completing the training requirement.

12.3 Laser-specific Training

Laser users are also responsible for knowing the safety requirements that apply to their specific laser or laser system and for knowing the contents of the applicable SOP.

13. LASER RELATED NON-BEAM HAZARDS & CONTROL MEASURES

While beam hazards are the most prominent laser hazards, other hazards pose equal or possibly greater risk of injury or death. These hazards must be reviewed by the EHS Department and addressed by the PLU in the SOP for the laser operation where applicable.

13.1 Electrical Hazards

Some lasers use high-voltage power supplies, large capacitors, or capacitor banks that present a lethal shock hazard. Additional hazards of electrical equipment include resistive heating and ignition source. Electrical safety controls include:

(a) OSHA [29 CFR 1910 S] requires additional controls and training for work on live circuits operating a more than 50 volts; note also that capacitors maintain a lethal charge even in de-energized and unplugged equipment. Use extreme caution if servicing laser power supplies.

(b) Review and comply with the Electrical Code (EEC).

(c) Check the condition of electrical insulation and ensure that electrical terminals are covered; repair or replace damaged equipment.

(d) Ensure good equipment grounding (i.e. chassis/frame resistance to ground limited to a few ohms).

(e) Follow good wiring practices (e.g. use GFCI outlets, no wires on the floor, no overloaded circuits, etc.).

(f) Use equipment only for its intended/designed purpose.

(g) Keep equipment “power up” warning lights clearly visible.

13.2 Laser Dyes

Dyes used as the optically active medium in some laser are often toxic and/or carcinogenic chemicals dissolved in flammable solvents. This creates the potential for personnel exposures above permissible limits, fires, and chemical spills. For each dye used, the PLU must have the MSDS available for staff review to ensure compliance with applicable CNSE Hazard Communication Procedure EHS-00002 governing hazardous chemical use and disposal.

13.3 Compressed Gases and Cryogenics

Hazardous gases may be used in laser applications; i.e. excimer lasers (fluorine, hydrogen chloride). Cryogenic fluids are used in cooling systems of some lasers. The SOP should contain references for the safe handling of compressed gases.

13.4 Laser Generated Air Contaminants

13.4.1 Air contaminants may be generated when Class 3B and Class 4 laser beams interact with matter.

13.4.2 When target irradiance reaches a threshold of about 10^7 W/cm^2, target materials including plastics, composites, metals, and tissues may liberate toxic and noxious airborne contaminants.

13.4.3 Generally, the PLU must ensure that any laser operation that creates visible smoke or plume has adequate local exhaust ventilation in place and included in the SOP; respiratory protection is not an acceptable alternative to local exhaust ventilation. If, in addition to local exhaust ventilation, respiratory protection is required or worn voluntarily, consult the CNSE Respiratory Protection Program.

13.5 Plasma Radiation

Interactions between very high power (~10^{12} W/cm^2) laser beams and target materials may produce a plasma, which in turn generates "blue light" and UV emissions that pose an eye and skin hazard. Similarly, targets heated to very high temperatures (e.g. in laser welding and cutting) emit an intense light. The PLU must ensure adequate control measures are in place and addressed in the SOP for such operations.

13.6 UV and Visible Radiation

Laser discharge tubes and pump lamps may generate sufficient UV and visible radiation to pose an eye and skin hazard. To address this issue, maintain the integrity of the laser housing and avoid operating any laser with the housing removed.

13.7 Explosion Hazards

High-pressure arc lamps, filament lamps, and capacitors may explode if they fail during operation. Keep these components enclosed in the laser housing, which will withstand the maximum explosive forces that may be produced. Laser targets and some optical components also may shatter if heat cannot be dissipated quickly enough. Ensure adequate mechanical shielding when exposing brittle materials to high intensity lasers.

13.8 Ionizing Radiation (X-rays)

X-rays could be produced from two main sources: high voltage vacuum tubes of laser power supplies such as rectifiers and thyratrons and electric discharge lasers. Any power supplies that require more than 15 kilovolts may produce enough x-rays to be a health concern. Consult EHS for review and control of such hazards.

14. MEDICAL SURVEILLANCE

14.1 Personnel working with Class 3B and/or Class 4 lasers or laser systems are required to obtain a baseline ocular exam prior to working with class 3B and/or class 4 lasers or laser systems.

14.2 Following any suspected laser injury, employees must report to a supervisor and EHS if they believe that they have been injured.

14.3 See Appendix D for further information on the Policy for Laser Eye Exams

15. LASER ACCIDENTS

15.1 Immediate Response and General Procedures

15.1.1 General Laser Accident Reporting

Laser users must report all laser accidents on site, no matter how minimal, to the PLU responsible for the laser system involved. The PLU must report any accidents causing injury or property damage to the EHS Department. If immediate assistance from the EHS Department is required, dial 78600 or (518) 437-8600 and indicate to the Security person that a laser accident has occurred, and direct them to notify the EHS Department to respond to the situation.

15.1.2 Known or Suspected Laser Overexposure

If a known or suspected overexposure to laser radiation occurs at the facility:

a. Seek medical care for the individual(s) exposed without delay from the Occupational Health Center open between the hours of 8:00 AM and 5:00 PM. If an incident occurs outside the Occupational Health Center's operating hours, seek assistance from the local Emergency Department by calling 911. Take all seriously injured persons directly to the Emergency Department at the closest hospital.

b. Notify the supervisor of the injured individual(s) to ensure action is taken to prevent any further injury to other personnel. The supervisor shall notify the EHS Department within 24 hours after the initial reporting of the incident. The EHS Department will inform Occupational Health Center and other relevant personnel of actions being taken or required as part of the medical investigation.

c. Complete an injury report form and submit to the EHS Department within 24 hours.

16. STANDARD OPERATING PROCEDURE (SOP)

16.1 An approved written SOP must be provided by the PLU for all Class 3B and Class 4 laser systems. This SOP should cover laser operations (e.g. description of activities and controls, identification and mitigation, routine alignment procedures, schematics of laser set-up) and other relevant hazards in the laser environment. The use of the template is highly recommended. The template provides a guide for the laser user in

identifying the characteristics of the laser operation and collateral hazards, and in formulating set-up and alignment procedures.

16.2 Contact the EHS Department for assistance in developing control measures and completing the SOP.

16.3 In the case of enclosed systems (e.g. laser scanning confocal microscopy) an abbreviated SOP can be applied after an experimental review by the EHS Department, who will then determine the SOP sections required. This abbreviated SOP follows the standard SOP approval process.

16.4 All SOPs need to be reviewed annually by personnel working with lasers to ensure the accuracy of the procedure(s). If no new hazards have been added to the system, the users can perform the review without notifying the EHS Department. If new hazards (use of a sub-nanosecond laser system, for example) have been added to the experiment, a review by the EHS Department is necessary to assure all applicable safeguards have been satisfied.

16.5 A specified time period, agreed upon by both the PLU and the EHS Department, will be established between the setting up of the laser equipment and the submittal of the SOP draft document. With the assistance of the user the EHS Department will develop a set of documented conditions for the laser user to operate the laser during the interim. These conditions will be posted in the laser environment and sent to the appropriate departmental safety coordinator.

17. RECORDS

All laser inventories and laser SOPs shall be kept on file in the EHS Department. Written records of registered lasers shall also be kept available for examination by the NYSDOL commissioner.

17.1 All class 3B and class 4 laser inventories shall be kept on file with the EHS department.

17.2 The results of each required initial laser output check and system interlock check.

17.3 Each transfer, receipt and disposal of any registered laser.

17.4 Annual inventories, safety eyewear checks and equipment measurements.

17.5 Medical history and ocular history test results.

17.6 Training records.

18. APPENDICES

18.1 **Appendix A** – Maximum Permissible Exposure Limits

18.2 **Appendix B** – Attenuation of Laser Safety Eyewear

18.3 **Appendix C** – NHZ Distance Values for Various Lasers

18.4 **Appendix D** – Policy on Laser Eye Exams for Class 3B and 4 Users

APPENDIX A
MAXIMUM PERMISSIBLE EXPOSURE LIMITS

	Wavelength	---------- MPE level (W/cm^2) ----------			
Laser type	**(µm)**	**0.25 sec**	**10 sec**	**600 sec**	**30,000 sec**
CO2 (CW)	10.6	---	100.0×10^{-3}	---	100.0×10^{-3}
Nd: YAG (CW)	1.33	---	5.1×10^{-3}	---	1.6×10^{-3}
Nd: YAG (CW)	1.064	---	5.1×10^{-3}	---	1.6×10^{-3}
Nd: YAG (Q-switched)	1.064	---	17.0×10^{-6}	---	2.3×10^{-6}
GaAs (Diode/CW)	0.840	---	1.9×10^{-3}	---	610.0×10^{-6}
HeNe (CW)	0.633	2.5×10^{-3}	---	293.0×10^{-6}	17.6×10^{-6}
Krypton (CW)	0.647	2.5×10^{-3}	---	364.0×10^{-6}	28.5×10^{-6}
	0.568	31.0×10^{-6}	---	2.5×10^{-3}	18.6×10^{-6}
	0.530	16.7×10^{-6}	---	2.5×10^{-3}	1.0×10^{-6}
Argon (CW)	0.514	2.5×10^{-3}	---	16.7×10^{-6}	1.0×10^{-6}
XeFl (Excimer/CW)	0.351	---	---	---	33.3×10^{-6}
XeCl (Excimer/CW)	0.308	---	---	---	1.3×10^{-6}

APPENDIX B
ATTENUATION OF LASER SAFETY EYEWEAR

			Suggested Maximum Incident Density		
O.D.	Attenuation (db>**	Attenuation Factor	1-switched Max. Energy Density ($J/cm^{2)}$	Non-Q-switched Max. Energy Density(j/cm^2)	Continuous Wave Maximum Power Density(W/cm^2)
1	10	10	10^{-6}	10^{-5}	10^{-4}
2	20	10^2	10^{-5}	10^{-4}	10^{-3}
3	30	10^3	10^{-4}	10^{-3}	10^{-3}
4	40	10^4	10^{-3}	10^{-2}	10^{-1}
5	50	10^5	10^{-2}	10^{-1}	1
6	60	10^{-6}	10^{-1}	1	10
7	70	10^7	1	10	
8	80	10^8	10	10^2	

* Because of limitations of safety eyewear material, no eyewear shall be exposed to more than 400 joules or 10 watts of incident laser energy or power, respectively.

** (db) = Decibel. A unit to express a beam intensity ratio. The decibel is equal to 10 times the logarithm of the beam intensity ratio expressed by the following equation:

$n(db) = 10 \log_{10} (P^1)/(P^2)$

where P1 and P 2 designate the input and output power density or energy density, respectively, and "n" designates the number of decibels corresponding to their ratio

APPENDIX C
NHZ DISTANCE VALUES FOR VARIOUS LASERS

Laser type	Exposure criteria	----- Hazard range (meters) ----- Diffuse	Lens-on-laser	Direct
Nd:YAG				
100 Watt	8 hours	1.4	11.3	1410
1.064 µm	10 seconds	0.8	6.3	792
CO_2				
500 Watt	8 hours	0.4	5.3	309
10.6 µm	10 seconds	0.4	5.3	390
Argon				
5.0 Watt	8 hours	12.6	1.7×10^3	25.2×10^3
0.488 µm	0.25 seconds	0.25	33.3	240

Laser criteria used for NHZ distance calculations:

Laser parameter	Nd-YAG	CO_2	Argon
Wavelength (µm)	1.064	10.6	0.488
Beam power (Watts)	100.0	500.0	5.0
Beam divergence (mrad)	2.0	2.0	1.0
Beam size at aperture (mm)	2.0	20.0	2.0
Beam size at lens (mm)	6.3	30.0	3.0
Lens focal length (mm)	25.4	200.0	200.0
MPE for 8 hours (w/cm^2)	1.6×10^3	1.0×10^5	1.0
MPE for 10 seconds (w/cm^2) 5.1×10^3	1.0×10^5	---	
MPE for 0.25 second (w/cm^2)	---	---	2.5×10^3

APPENDIX D
POLICY FOR LASER EYE EXAMS
FOR CLASS 3B AND CLASS 4 LASERS USERS

I. Scope

This policy applies to all CNSE individuals directly involved with the use of Class 3B and Class 4 lasers in the following facilities: NanoFab South, South Annex, NanoFab North, CESTM, Physics and Chemistry Incidental workers (e.g. custodial, clerical and supervisory personnel may be required to have eye exams as determined by the Laser Safety Officer.)

II. Purpose

To establish the CNSE Policy for pre-assignment eye exams (Baseline Eye Exam), periodic eye exams, termination eye exams, and incident-related eye exams. These requirements reflect those stated in ANSI Z136.5-2009, Appendix G, Medical Surveillance.

Supervisors of laser installations are requested to publicize this policy and are responsible that these requirements are met.

III. Requirements

A. Pre-assignment Medical Exams

1. Laser personnel who work routinely in Class 3B and Class 4 laser environments shall have a pre-assignment medical exam to establish a baseline against which ocular damage may be measured. Laser personnel supporting CNSE shall complete this special laser eye examination before they are allowed in the laser danger area. The examination shall include:

    - Medical histories
    - Visual acuity
    - Ocular history
    - Amsler grid test for macular health
    - Color vision test (Ishihara)
    - Ocular fundus (to be administered to individuals whose ocular function in one of the above tests is not normal)
      Reference ANSI Z136.5-2009, Section 6, Appendix G.

These examinations shall be performed by, or under supervision of an ophthalmologist or other specified in ANSI Z136.5-2009, Section G2.1.1. Records of these results shall be maintained in the individual's medical file and sent to the EHS Office as confidential personnel records at the sites.

B. Periodic Eye Examinations

Periodic eye examinations are not required.

C. Termination Eye Examination

Termination eye examinations for all laser personnel shall use the Pre-assigned Medical Exam as defined in Section III. This examination will document their visual status at the time of termination from Albany NanoTech.

Complete and accurate records of all medical examinations shall be maintained for all personnel included in the medical surveillance program.

D. Incident-related Eye Exams

In the event of any accidental or suspected eye exposure to laser radiation, a thorough eye examination shall be conducted as specified in ANSI Z136.5-2009, Section 6 and Appendix G. Records of these results shall be maintained in the individual's medical file in the EHS Office.

IV. Examination Protocol

Laser facility supervisors shall provide a list, in writing, of those individuals requiring laser eye exams. This list shall be given to the EHS Department with a copy to the Group Leader or Professor.

Each individual shall receive a copy of this policy prior to going to the exam.

The Group Leaders/Professors shall maintain a list of individuals requiring and completing eye exams. A copy of this list shall be sent to the EHS Department on a quarterly basis.

Results of individual eye exams shall be maintained as part of the individual's medical records and as specified in ANSI Z136.5-2009, Section 6 and Appendix G.

V. Prescription Laser Safety Glasses

When necessary, prescription laser glasses will be provided to authorized personnel by CNSE.

Any person requiring prescription laser glasses or laser safety glasses shall send a request via email to the EHS Department. The EHS Department will be responsible for ordering such glasses.