LASER SAFETY 10/15/2007

1. Purpose:

To establish an administrative and operational plan for a safe and healthy work and research environment for laboratory administrators, managers, faculty, staff, and students using lasers.

2. Authority:

1. American National Standard for Safety Use of Lasers ANSI Z136.1-2007.
    a. Optical Fiber Communication Systems
    b. Lasers in Health Care Facilities
    c. Lasers in Educational Institutions.
2. International Electrotechnical Commission IEC 60825-1.2 – 2001.
3. US Department of Health and Human Services.
4. U.S. Department of Labor, Occupational Safety & Health Administration,
5. Center for Devices and Radiological Health (CDRH)
6. Illinois Emergency Management Agency (IEMA)

3. Scope:

3.1 Applies to all principal investigators, laboratory managers, faculty, staff, students, medical, nursing, telecommunications personnel, guests and visitors.

3.2 Includes all Class 3b and Class 4 lasers, including embedded Class 3b and Class 4 lasers.

3.3 Includes all UIC facilities and applications in which these lasers are used, including but not limited to, research, education and training, medical diagnosis and therapy, telecommunications, manufacturing, and entertainment.

3.4 Excludes:

- All certified Class 1, Class 2, and Class 3a lasers, provided that the laser is maintained as a certified Class 1, Class 2 or Class 3a laser system throughout its useful life.
- Any operational, portable, non-medical laser system, removed from use to transport to a new UIC campus location.
- A laser system that is inoperable due to the absence or failure of components necessary for proper operation.

NOTE: Laser systems that are not in operation due to disconnection from an electrical supply shall be considered operable.

4. Definitions:

4.1 **Absorption** - The process by which some or all of energy is assimilated

4.2 **Accessible emission limit**, (AEL) -The maximum level allowed within a particular laser class to which human access is possible. AEL = MPE x (Area of Limiting Aperture)

4.3 **Aperture Stop** - an equipment opening that limits the size and shape of the beam area.

4.4 **Attenuation** - The decrease in the radiant flux as it passes through an absorbing or scattering medium.

4.5 **Beam** - A collection of rays which may be parallel, divergent, or convergent.

4.6 **Beam Diameter** - The distance between diametrically opposed points in that cross section of a beam where the power per unit area is the fraction 1 / e (0.368) times that of the peak power per unit area.

4.7 **Beam Divergence** - The full angle of the beam spread between diametrically opposed 1/e-irradiance points; usually measured in milliradians, where one milliradian = 3.4 minutes of arc.

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

4.9 **Cornea** - The transparent outer coat of the human eye which covers the iris and the crystalline lens. It is the main refracting element of the eye.

4.10 **Diffuse Reflection** - Change of the spatial distribution of a beam of radiation when it is reflected in many directions by a surface or by a medium.

4.11 **Discontinuance** - the process of discontinuing the use of a laser or laser system. This process is documented by notification to the IEMA within 30 days of the discontinuance and includes the date of discontinuance, name, address, and telephone number of the person receiving the laser and the disposition of the laser. NOTE: Laser systems that are not in operation due to disconnection from an electrical supply shall be considered operable.

4.12 **EHSO** - the Environmental Health and Safety Office at the University of Illinois at Chicago.

4.13 **Enclosure** - a protective housing that covers the laser or laser system. By opening or removing the protective housing provides additional access to the laser radiation above the applicable MPE than possible with the protective housing in place.

4.14 **Embedded laser** - an enclosed laser classified with a number higher than the capability of the system in which it is encased. A lower classification is permitted due to engineering controls that limit accessible emissions.

4.15 **Extended Source** - An extended source of radiation can be resolved by the eye into a geometrical image, in contrast to a point source of radiation, which cannot be resolved into a geometrical image.

4.16 **FAA** – The Federal Aviation Administration

4.17 **Human access** - the ability to expose laser or collateral radiation to any part of the human body or to reflected laser radiation in Class 3b and Class 4 lasers.

4.18 **IEMA** - the Illinois Emergency Management Agency (Department of Nuclear Safety)

4.19 **Incident** - an event or occurrence that results in a real or suspected intentional or accidental exposure to laser radiation that caused or has the potential to cause biological damage.

4.20 **Infrared Radiation** - Electromagnetic radiation with wavelengths which lie within the range 0.7 μm to 1 mm.

4.21 **Intra-beam Viewing** – the eye is exposed to all or part of a laser beam.

4.22 **Invisible radiation** - having wavelengths of equal to or greater than 180 nm but less than or equal to 400 nm or greater than 710 nm but less than or equal to 1.0 X 106 nm (1 millimeter).

4.23 **Irradiance** - radiant power incident on an element of a surface divided by the area of that element, expressed in watts per square centimeter (W/cm2).

4.24 **Laser** - A device which produces an intense, coherent, directional beam of light by simulating electronic or molecular transitions to lower energy levels. LASER is an acronym for Light Amplification by Simulated Emission of Radiation. It produces or amplifies electromagnetic radiation at wavelengths greater than 250 nm but less than or equal to 13,000 nm or, after August 20, 1986, at wavelengths

equal to or greater than 180 nm but less than or equal to 1.0X106 nm primarily by the process of controlled stimulated emission.

4.25 **Laser Installation** - a location or facility where laser systems are produced, stored, disposed of or used for any purpose. In this case, the University of Illinois at Chicago.

4.26 **Laser safety officer**, (LSO) - any individual, qualified by training and experience in the evaluation and control of laser hazards, who is designated by the registrant to have the authority and responsibility to establish and administer the laser radiation protection program for a particular laser installation.

4.27 **Laser system** - an assembly of chemical, electrical, mechanical, and optical components and equipment which includes a laser.

4.28 **Lockout / Tagout**, (LOTO) - documented process required by OSHA for de-energizing equipment prior to any service or maintenance done to the equipment. LOTO procedures protect the employees working on the equipment from an accidental release of energy that could harm them.

4.29 **Maximum permissible exposure** (MPE) - the level of laser radiation to which a persons may be exposed without adverse biological change in the eye or skin.

4.30 **Medical laser** – a medical device manufactured, designed, intended or promoted for in vivo laser irradiation of any part of the human body for the purpose of diagnosis, surgery, therapy or relative positioning of the human body.

4.31 **Nominal Hazard Zone** - The location around the laser within which a person can be exposed to radiation in excess of the MPE.

4.32 **Operator** - an individual, group of individuals, partnership, firm, corporation or association conducting the business or activities carried on within a laser installation, also personnel who work routinely with lasers or laser systems.

4.33 **Optical density**, (OD) - a logarithmic expression of the optical attenuation afforded by a material OD = log[10] (incident power)/(transmitted power).

4.34 **Optical fiber communications system**, (OFS) - laser transmitter which is coupled via individual optical fiber for information transmission as in UIC Telecommunication systems.

4.35 **Protective housing** - those portions of a laser system that are designed to prevent human access to laser radiation above the applicable MPE level.

4.36 **Pulse duration** - time measured between the half-peak power points at the leading and trailing edges of a pulse.

4.37 **Pulsed Laser** - A laser which delivers its energy in the form of a single pulse or train of pulses. The duration of a pulse is considered to be 0.25s.

4.38 **Pupil** - The variable opening in the iris through which light travels.

4.39 **Q-switched Laser** - A laser which emits short (about 30ns), high-power pulses by utilizing a Q-switch (i.e., optically detuning the laser cavity).

4.40 **Radiant exposure** - the radiant energy incident on an element of a surface divided by the area of that element, expressed in joules per square centimeter (J/cm2).

4.41 **Radiant power** - power emitted, transferred or received in the form of laser radiation expressed in watts (W). Also means output power in J/sec.

4.42 **Research-Use Laser** - A laser that is purchased then modified, or a UIC designed prototype laser used for specific research applications.

4.43 **Registrant** - the UIC laser Operator or Primary Investigator who registers the laser or laser system with the UIC Environmental Health and Safety.

4.44 **Retina** - sensory membrane that lines the inside posterior of the eye to which receives the image formed by the lens. Converts light images to sensory impulses.

4.45 **Scanning Laser** - equipment with time-varying direction, origin or pattern of propagation compared to a stationary frame of reference.
4.46 **Specular Reflection** - A mirror-like reflection.
4.47 **Ultraviolet Radiation** - Electromagnetic radiation with wavelengths shorter than those for visible radiation. For the purpose of this standard, wavelengths which lie within the 0.2-0.4 nm range.
4.48 **Visible Radiation** (light) - Electromagnetic radiation which can be detected by the human eye. It is commonly used to describe range between 0.4 nm and 0.7 nm.

5. Procedures - General

5.1 Registration:

5.1.1 UIC is legally obligated to register laser systems both initially and annually with IEMA prior to operation.
5.1.2 Registration to IEMA is completed by EHSO on the prescribed IEMA form.
5.1.3 No laser equipment may be installed or operated until EHSO is notified and the conditions in this policy have been completely met is determined by the LSO.
5.1.4 The following information must be provided initially to the EHSO:

- building and room number of the laser system
- primary laser operator name
- classification number of the laser
- serial number, manufacturer and model of the laser
- output power and wavelength of the laser
- floor plan with layout information of the laser use area
- disposition of the laser if discontinued, including the recipient's name, address and telephone number

5.1.5 Changes to a laser system must also be reported within 5 working days to EHSO. EHSO will provide LSO assessment and IEMA notification within the mandatory 30 days. This includes the discontinuance of a laser system.
5.1.6 Class 3b or Class 4 laser systems brought into UIC for temporary use (e.g. loan, renting, leasing, trial etc.) must be registered with EHSO and IEMA.
5.1.7 Contact the LSO for assistance when requesting out-of-state or out-of-country, Class 3b or Class 4 laser(s) or embedded systems to be brought to UIC for evaluation or short term use. Note, the PI must provide written notice to the EHSO 15 working days prior to receipt of any system at UIC. The EHSO shall submit a laser registration notice to IEMA at least 10 working days prior to the laser system being used.
The EHSO requires compliance with this policy and written, specific data from the PI that shall include the nature, duration and scope of use of the laser system, and the exact location where the laser system will be used. The LSO will ensure laser system registration with IEMA. Notify the LSO to perform a pre-operational inspection at least 24 hours prior to UIC use. This inspection may be reviewed by IEMA.

5.1.8 UIC Experimental, Prototype lasers of all classifications 2 and above, must be reviewed and inspected by EHSO prior to use. Experimental and prototype systems require EHSO registration with IEMA.

5.1.9 Should IEMA require a registration fee, this fee will be paid by EHSO or by Miscellaneous Funds Transfer Voucher to EHSO, depending on the institution / facility involved in accordance with UIC accounting policies.

5.2 Laser Safety Officer (and Deputy Laser Safety Officers:)

5.2.1 The LSO, designated by the Director of Environmental Health and Safety, must demonstrate qualifications that include training, experience and familiarity with laser operations and laser safety as identified by IEMA Title 32 Chapter II Subsection B Part 315.

5.2.1.1 The LSO must have successfully completed a Laser Safety officer course by a recognized organization or school such as the Laser Safety Institute.

5.2.1.2 The LSO must have verifiable experience with laser systems and their safe operation.

5.2.2 The LSO reports to the Director of Environmental Health and Safety.

5.3 Laser Safety Committee:

6.3.1 The Vice Chancellor for Administrative Services, in consultation with the LSO and Director of EHSO, appoints members to this committee from representatives from the campus community.

6.3.2 The committee includes an administrative representative, a laser-user scientist, a laser/equipment engineer, a medical laser-user, an operating room nurse with laser experience and training, the LSO, and any other members felt needed by the committee.

5.4 Laser Operator Personnel Qualifications:

5.4.1 Only personnel who have successfully completed the initial and annual UIC Laser Safety Training program and have demonstrated competency in laser use are permitted to operate laser equipment. Competent laser use shall be evaluated by the program PI and/or LSO.

5.4.2 Agrees to operate laser equipment only according to approved UIC Standard Operating Procedures.

5.4.3 Has received a baseline medical surveillance from the University Health Services department. Baseline protocols are outlined in Section 9.0 of this procedure.

5.4.4 Has received training and proper clearance for non-beam hazards associated with laser use, such as the use of hearing protection.

5.4.5 Has been provided the correct and necessary personal protective equipment, such as laser safety goggles of the correct optical density for the specific wavelength.

5.5 Written Standard Operating Procedures:

5.5.1 Each laser system operator or Primary Investigator (PI) is required to develop written standard operating procedures (SOPs) for the specific safety requirements to operate the laser. This includes alignment procedures, safe operating limits, emergency procedures and calibration procedures for the laser system. The SOPs provided by IEMA in Appendix D are recommended as templates.

5.5.2 The SOPs must include the safety information and operating instructions provided by the laser manufacturer as required by the FDA.3.5.3. The LSO must review and approve the SOPs and ensure that they are being followed.

5.5.4 Non-beam hazard control policies and procedures must be followed where applicable. Any questions concerning non-beam hazard evaluation and control measures, please contact the On-Call Safety Officer at (312) 996-SAFE (7233).

5.6 Training:

5.6.1 Initial and annual training is required by IEMA for all personnel operating, maintaining and servicing lasers.

5.6.2 Training shall consist of a General Laser Safety Training Program conducted quarterly by the LSO in pre-announced, regularly scheduled sessions.

5.6.3 Training shall also consist of Laser-Specific Training that includes specific manufacturer's instructions.

5.6.4 Topics in the laser-specific training must include, but are not limited to:

- Standard operating procedures for each laser system.
- Laser system safe operating limits and Maximum Permissible Exposure limits (MPE)
- Emergency procedures and reporting requirements.
- Laser optical system alignment and calibration.
- Warning signs and labels.
- Engineering hazard controls such as safety interlocks, viewing optics and warning systems.
- Administrative controls such as establishing controlled areas, escort and protection of visitors.
- Policies and control measures for non-beam hazards, such as electrical hazards, excessive noise, or hazardous plume formation.
- Selection and use of personal protective equipment.
- Methods used to detect the presence or release of laser light
- Location of reference material on lasers.

5.6.5 Web-based training may also be provided by the LSO in lieu of lectures.

5.7 Beam Alignment:

5.7.1 Mirrors, lenses and beam deflectors must be aligned in accordance with manufacturer's instructions and as identified in the standard operating procedure, (SOP) for the laser so that no one is exposed to laser radiation above the MPE when at all possible.

5.7.2 Following an evaluation of the expected beam path and potential hazards from reflective surfaces, all reflective surfaces must be excluded from the path at all points where the laser radiation exceeds the MPE.

5.8 Beam Hazard Administrative Controls:

5.8.1 The LSO or authorized designee will conduct periodic safety audits to identify and recommend corrective actions for unsafe release of hazardous laser light.

5.8.2 A laser controlled area must be established when a hazard analysis determines the laser radiation may be in excess of the MPE limit.

5.8.2.1 A controlled area is an area where the occupancy and access is subject to the control and supervision of the Primary Investigator to provide protection from laser hazards.

5.8.2.2 Only the LSO or trained designated representative as determined by the LSO may allow access.

5.8.2.3 Controlled areas must be posted with the required IEMA warning signs for the type of laser in use. See Appendix E for proper laser labeling, wording and warning signs.

5.8.2.4 The following recommendations should be included with a Class 3B or Class 4 controlled area.

Class 3B laser controlled area guidelines;

- Posting with appropriate warning signs at the entryway(s)
- only trained operators use the system;
- Limit the beam path;
- Limit access;
- Use beam stops;
- Have only diffuse reflected material near the beam;
- Provide personnel with appropriate eye protection;
- Have beam path at height other than eye level;
- Disable the system when not in use

Class 4 laser controlled area guidelines in addition to Class 3B controls;

- Follow appropriate SOPs;
- Be appropriately trained for this laser class;
- Have a designated route for rapid egress;
- Clearly marked emergency use "Panic Button";
- Incorporate EHSO, LSO approved area and entry-way controls, to prevent an exposure in the case of an inadvertent entry, where controls may be non-defeatable, defeatable or procedural.

5.8.3 Caution Signs, Labels and Postings:

5.8.3.1 Only IEMA approved signs and postings may be used. See Appendix E for proper laser labeling, wording and warning signs.
5.8.3.2 Class 3b and Class 4 lasers must be posted with specific IEMA wording. See Appendix E for proper laser labeling, wording and warning signs.
5.8.3.3 All lasers, except those used in medical procedures, must have labels in close proximity to each aperture through which energies > MPE are possible. IEMA prescribes specific wording. See Appendix E for proper laser labeling, wording and warning signs.
5.8.3.4 Specific IEMA requirements must be met for such lasers as those outside the range of 400 to 710 nanometers, other wavelengths, and non-interlocked or defeatable interlock protective housings.
5.8.3.5 Consult the LSO upon installation of any new laser system or any change in an existing laser system for the proper labels, signs and postings in compliance with IEMA.

5.8.4 No individual may be exposed to levels of laser radiation higher than the IEMA prescribed MPE as provided in Appendix B.

5.8.4.1 When no MPE is known for a particular wavelength and pulse duration, exposure is prohibited.
Measurements and calculations for MPE limit determination must be consistent with the ANSI Z136.1-2000 criteria. See Appendix A and Appendix C for MPE tables, calculation formulas, correction factors and aperture diameters.
5.8.4.3 The minimum laser energy necessary for the procedure should be used.

5.8.5 Controls are required for unattended laser equipment.

5.8.5.1 To be left unattended, de-energize the power supplies or capacitor banks by following the appropriate Lock-Out/Tag-Out, LOTO procedure for the equipment.
5.8.5.2 Remove the keys from switches or interlocks to prevent unauthorized activation of the equipment.
5.8.5.3 The operation of unattended lasers is only allowed when a specific SOP has been approved by the Principal Investigator and LSO.

5.9 Engineering Controls:

5.9.1 Protective housing is required to prevent access to laser radiation that exceeds the limits of a Class 1 laser when access is not necessary to perform the procedure.
5.9.2 Safety Interlocks that ensure that laser radiation is not above MPE limits are required for protective housings that can be removed without tools.
5.9.3 Pulsed lasers must have interlocks to prevent firing.
5.9.4 Continuous wave lasers must have interlocks that turn off the power supply or interrupt the beam.

5.9.5 Multiple safety interlocks are required if failure of one interlock would allow access to Class 3b or Class 4 laser radiation.
5.9.6 Viewing optics and windows must have a means to attenuate to less than the MPE during maintenance or operation.
5.9.7 When optical systems are not part of a certified laser product, the LSO must determine the hazard and specify hazard controls.
5.9.8 Visual or auditory warning systems must indicate emission of accessible laser radiation.
5.9.9 Visual indicators must be visible through safety eyewear and be positioned so that laser radiation exposure above the MPE does not occur.
5.9.10 Warning indicators must be provided prior to laser radiation emission in order to allow exposure avoidance.

5.10 Personal Protective Equipment:

5.10.1 PPE is to be used only when administration and engineering controls are inadequate to eliminate potential exposure above the MPE.
5.10.2 Eyewear must be of the required optical density for the wavelength of the laser.
5.10.3 Eyewear must be inspected every six months by the Principal Investigator or LSO appointed designee, to ensure reliability and integrity.
5.10.4 Eyewear must be comfortable and appropriately fitted to each individual.
5.10.5 Laser protective eye wear must be approved by the American National Standards Institute (ANSI) and clearly labeled with optical densities and wavelengths for which protection is afforded. No other eyewear is permitted for laser safety. Consult the LSO for recommendations.
5.10.6 Protective gloves, clothing and shields must be used when there is a potential for exposure that exceeds the IEMA MPE limits for skin.

6.0 Procedures - Specific Applications and Events

6.1 Indoor Class 4 Laser Controlled Areas:

6.1.1 Latches, interlocks or other appropriate means shall be used to restrict access to controlled areas.
6.1.2 Control measures shall be designed to allow both rapid exit by the laser personnel at all times and entrance to the controlled area in an emergency condition.
6.1.3 A control-disconnect switch or equivalent device (panic button) shall be available for deactivating the laser or closing the shutter in an emergency situation.
6.1.4 During continuous laser / laser system operation, a trained designated representative shall be permitted to momentarily override safety interlocks allowing access to the secure area by other authorized personnel. This is allowed if it is clearly evident that no optical radiation hazard exists at the point of entry. All personnel are required to have available and wear necessary protective devices PPE prior to entering the secure area.
6.1.5 Optical paths (e.g., windows) of an indoor facility shall be controlled in such manner as to reduce laser radiation emissions to levels at or below

the MPE. When the laser beam must exit the indoor controlled area (as in the case of exterior atmospheric beam paths), the PI and operator shall be responsible to ensure the beam path is limited to controlled air space or controlled ground space when the beam irradiance or radiant exposure is above the appropriate MPE. Consult Section 10 for references to regulations for atmospheric beam paths having an opportunity for “sky-shine”.

6.2 Infrared Laser Systems:

6.2.1 The beam from an infrared laser (wavelength greater than 710 nanometers) shall be terminated in fire-resistant material where necessary.
6.2.2 The Principal Investigator shall conduct periodic inspection of fire-resistant material to ensure the material has not degraded with use.
6.2.3 Any degraded material that could create a fire or reflection hazard shall be replaced prior to further operation of the laser.

6.3 UIC Telecommunications - Optical Fiber Communication Laser Systems:

6.3.1 Laser communication systems employing optical cables shall be considered enclosed systems. The optical cable connector forms part of the protective housing.
6.3.2 Removal of an active optical cable from the protective housing may result in radiation levels exceeding the applicable MPE. Removal of optical cables shall take place only in a controlled area by personnel wearing appropriate PPE.
6.3.3 The use of a tool shall be required for the disconnection of a connector for service and maintenance purposes when the connector is not within a protective housing.
6.3.4 All connectors shall bear appropriate labeling.

6.4 UIC Medical Laser Applications:

6.4.1 Lasers must be calibrated by a trained individual in accordance with the manufacturer's specified calibration procedure at intervals not to exceed those specified by the manufacturer.
6.4.2 Calibration records must be maintained in the medical facility at each machine in a readily accessible area for review by the LSO and for inspection by the IEMA.
6.4.3 Each medical laser must incorporate a means for measurement of the level of laser radiation intended for human irradiation, with an error in measurement of no greater than plus or minus 20 percent, when calibrated in accordance with the laser manufacturer's calibration procedure.
6.4.4 Any footswitch that is used to control patient exposure to laser radiation must have a guard mechanism to prevent inadvertent exposure.
6.4.5 Medical lasers must not be used for human irradiation unless the above requirements are met and the equipment is in proper calibration and operating condition.
6.4.6 Coaxial cooling appropriate to the procedure must be used in lieu of gas to purge a fiber in the intrauterine cavity.

6.4.7 Never operate the laser unless the aiming beam and fiber tip are visible beyond the end of the endoscope.

6.4.8 Watch the fiber for beam distortion, decreased power, and debris accumulation. Ensure the laser is "off" and use caution when removing debris from lenses, filters and distal tips.

6.5 UIC Pavilion and Miscellaneous Departments - Entertainment Laser Light Shows and Outdoor Use:

6.5.1 The UIC Pavilion staff and other UIC Departments shall notify the LSO in at least 15 working days in advance of the proposed laser light show, and provide the following information:

6.5.1.1 Name, address and telephone number of the:

- Laser registrant,
- Laser safety officer (non-UIC),
- Individual in charge of the laser light show,

6.5.1.2 The location, time and date of the show.

6.5.1.3 Documentation that a variance has been obtained in accordance with 21 CFR 1040.11, found on this website; www.fda.gov/opacom/morechoices/fdaforms/FDA-3147.pdf.

6.5.1.4 Manufacturer, class, wavelength and output power of the laser systems to be used.

6.5.1.5 Sketches showing the location of the laser systems, operators, performers, laser beam paths, viewing screens, walls, mirror balls and other reflective or diffusive surfaces that may be struck by the laser beam.

6.5.1.6 For outdoor performances, a copy of the notification to the Federal Aviation Administration.

6.5.1.7 Copy of registrant/operator training certification.

6.5.2 The LSO shall notify IEMA in writing or by fax of the above information at least 10 days in advance along with any additional information requested.

6.5.3 Requirements for Safe Operations

6.5.3.1 Laser radiation emissions outside the spectral range of 400 to 700 nm, shall not exceed the limits of a Class 1 laser.

6.5.3.2 Levels of laser radiation, where the audience is located, and where operators, performers and employees are located if the laser radiation is intended to be viewed by them, shall not exceed the limits of a Class 1 laser.

6.5.3.3 Operators, performers and employees shall be able to perform their functions without being exposed to laser radiation exceeding the limits of a Class 2 laser when the laser radiation is not intended to be viewed by them.

6.5.3.4 Areas where levels of laser radiation exceed the limits of a Class 2 laser shall be identified by posting of warning signs and through use of barriers or guards to prevent individuals from entering these areas.

6.5.3.5 Scanning lasers shall not, as a result of scan failure or any other failure causing a change in either angular velocity or amplitude, permit audience exposure to laser radiation in excess of the limits of a Class 1 laser.

6.5.3.6 Where a mirror ball is used with a scanning laser, these conditions shall be met with the mirror ball stationary or during any failure mode resulting in a change in rotational speed of the mirror ball.

6.5.3.7 Laser light shows shall be, at all times, under the direct and personal supervision of the laser operator, except:

- In cases where the maximum laser output power level is less than 5 milliwatts (all spectral lines);
- When the laser beam path is located at least 6 meters above any surface upon which an individual in the audience is permitted to stand; or
- When the laser beam path is located at least 2.5 meters in lateral separation from any position where an individual in the audience is permitted during the performance.

6.5.3.8 Laser radiation levels shall not exceed the limits of a Class 2 laser at any point less than 3 meters above any surface upon which any individual in the audience is permitted to stand, and 2.5 meters in lateral separation from any position where an individual in the audience is permitted, unless physical barriers are present that prevent human access to these levels.

6.5.3.9 All safety devices and procedures necessary to comply shall be functionally tested and evaluated after setup and prior to the laser light show to ensure compliance.

6.5.3.10 The laser system, when not in use, shall be secured against unauthorized operation or tampering.

6.5.3.11 Laser alignment procedures shall be performed with the laser output power reduced to the lowest practicable level, and protective eyewear shall be worn to prevent exposure to laser radiation levels exceeding the MPE. Unless specifically authorized by the laser safety officer, only individuals required to perform the alignment shall be present during these procedures.

6.5.3.12 The operator shall ensure that no laser light show is conducted except as specifically authorized in a variance issued in accordance with 21 CFR 1040.11 and applicable requirements of IEMA regulations. (See the Section, References and Regulations for further guidance)

6.6 UIC Research / Experimental Laser Applications:

6.6.1 It is the responsibility of the Principal Investigator to classify and label experimental, prototype and UIC-made lasers in accordance with 21 CFR 1040 requirements. Contact the LSO for guidance during the design phase of the laser.

6.6.2 Contact EHSO for instructions on laser registration, application for experimental use, approval of appropriate UIC committees and other regulatory and control requirements

6.6.3 Lasers that are purchased and modified or are "hand-made" from components for research and/or experimental use shall comply with the following sections of this procedure:

5.1 Registration
5.4 Laser Operator Personnel Qualifications
5.6 Training
5.7 Beam Alignment
5.8 Beam Hazard Administrative Controls
5.10 Personal Protective Equipment
5.0 Control of Non-Beam Hazards
8.0 Medical Surveillance
9.0 Recordkeeping

6.6.4 (Reserved: Research / Experimental Laser General Procedures)

6.7 Laser Pointers:

6.7.1 These products are generally safe when used as intended by professors and lecturers to highlight areas on a chart or screen.
6.7.2 The light energy from laser pointers should not be aimed into the eyes of the presenter or audience. This can be more damaging than staring directly into the sun.
6.7.3 Federal law requires a warning on the product label about this potential hazard to the eyes.

6.8 Emergency Procedures and Incident Reporting:

6.8.1 For all laser injuries, laser lab personnel will contact the EHSO at (312) 996-SAFE (7233).

6.8.2 For possible eye injuries, laser lab personnel will ensure the following:

- Keep the person elevated in a "heads-up" position, if possible.
- Keep the person calm.
- Call the UIC Police at (312) 996-HELP (6-4357) to obtain assistance.
- Notify the LSO via the on-call Safety Officer at (312) 996-SAFE (6-7233).
- Shut down the laser system until evaluation and corrective actions are completed.
- Notify the Principal Investigator or supervisor.
- Ensure that the victim receives follow-up care from an ophthalmologist if initial care is provided by the emergency department.

6.8.3 For possible skin injuries, laser lab personnel will ensure the following:

- Control excessive bleeding using an ice pack while applying direct pressure with a gloved hand.
- Keep the person calm.
- Call the UIC Police at (312) 996-HELP (6-4357) to obtain assistance.
- Notify the LSO via the on-call Safety Officer at (312) 996-SAFE

(6-7233).
- Shut down the laser system until evaluation and corrective actions are completed.
- Notify the Principal Investigator or supervisor.

6.8.4 Laser Incident Reporting:

6.8.4.1 The Principal Investigator will be responsible:

- To ensure completion of the "Supervisor First Report of Injury Form".
- To ensure full cooperation of all lab personnel with the investigation of the laser injury by the EHSO.
- To assist EHSO with the laser injury investigation.

6.8.4.2 The LSO and EHSO will be responsible for the laser injury follow-up report which includes the following:

- Visiting the accident site.
- Taking photographs.
- Conducting interviews.
- Determining the full name of each individual exposed, estimates of each individual's exposure, levels of laser radiation involved, and injury description.
- Determining the root cause.
- Instituting appropriate corrective action.
- Providing a verbal report to the EHSO Director
- Providing a written report to the Laser Safety Committee.
- Providing notification to IEMA immediately upon determination of an exposure greater than 100 X MPE, partial or total loss of sight in an eye, or skin perforation or other non-eye serious injury.
- Providing notification to IEMA within 24 hours upon determination of an exposure greater than 5 X MPE or 2nd or 3rd degrees skin burns.
- Providing a written report to the Director of EHSO to be forwarded to IEMA and to the individual within 30 days for the previous two notifications.

7.0 Control of Non-Beam Hazards

7.1 Electrical Hazards:

7.1.1 The electrical installation of the laser system must conform to the National Electric Code, NFPA 90.

7.1.2 During service or maintenance, the laser system must be de-energized using an OSHA Control of Hazardous Energey (Lock-Out/Tag-Out) procedure.

7.1.3 Only trained, authorized service personnel may perform service on laser systems.

7.2 Laser Generated Air Contaminants (LGAC):

7.2.1 Contact an EHSO Industrial Hygienist for assistance in evaluating a plume management system, such as a filtered smoke evacuator, or filtered collection port whenever LGAC's are anticipated from any protocol or procedure.
7.2.2 Ensure plume management system controls are in place and operating properly prior to using lasers where LGAC's may be generated.
7.2.3 Medical laser systems may place the distal collection port a distance no greater than 2 cm from the impact site when possible.

7.2.3.1 Collect medical LGAC using a 0.3m filter between wall suction and fluid canister for those suction lines connected to an evacuator.

7.3 Fire Hazards – Class 3b, Class 4 laser systems:

7.3.1 Never use alcohol or flammable liquids in the operative field. Fibers may be rinsed in saline or hydrogen peroxide.
7.3.2 Never place a hot fiber directly on paper drapes. Use fire-retardant drapes and dampened packs or pads.
7.3.3 Put the laser system in standby mode when the procedure is completed or interrupted.
7.3.4 Avoid high oxygen levels in the operative field.
7.3.5 Avoid exposure of flexible fiber endoscope sheaths to the laser beam.
7.3.6 Terminate and periodically inspect infrared lasers using a fire-resistant material.
7.3.7 Always inspect fibers for breaks or damage of the distal tip.

7.4 Laser Dyes/Chemicals:

7.4.1 Dye lasers commonly use a fluorescent powdered dye compound dissolved in an organic solvent.
7.4.2 Due to toxicity, mutagenicity, and potential carcinogenicity hazards posed by powdered dye compounds, these compounds must be handled by trained personnel using an approved, operating fume hood for this use.
7.4.3 All dyes and solvents must be regarded as hazardous chemicals that are possibly flammable and toxic by inhalation and/or skin absorption.
7.4.4 A Material Safety Data Sheet (available on the EHSO website) must be available for all dyes and solvents.
7.4.5 Handle and store all hazardous materials in accordance with the UIC Chemical Hygiene Plan, by visiting, www.uic.edu/depts/envh/, highlighting the Chemical Safety Topic.
7.4.6 Ensure integrity of the laser dye delivery system by pressure testing prior to loading and starting systems using dye solutions.

7.5 Noise:

7.5.1 EHSO safety staff will, on request, monitor the noise level in laser use areas.

7.5.2 If monitored noise levels exceed a 85dBA action level, 8 hour time-weighted average or when high levels of short time interval noise are monitored, EHSO will advise personnel of the appropriate PPE to wear, or provide insight to other methods to ensure adequate hearing protection in accordance with EHSO 5.3 Hearing Conservation available at www.uic.edu/depts/envh/.

7.6 Collateral Radiation:

7.6.1 Contact EHSO and the LSO prior to laser system use requesting a hazard assessment for collateral safety hazards, including but not limited to reflected laser emissions, radio frequency fields and possible generation of soft x-rays.
NOTE: During the laser system application review, the PI and LSO will address and evaluate collateral safety hazards. EHSO and the LSO will assist the PI to include appropriate controls to address collateral safety hazard issues.

8.0 Medical Surveillance

8.1 Laser operators or individuals who will work in areas with Class 3b or Class 4 lasers are offered a baseline eye examination prior to using the laser.
8.2 The baseline eye examination will include ocular history, visual acuity, Amsler grid test and color vision testing.
8.3 The baseline ocular history will help identify workers which might be at special risk from chronic exposure to certain CW lasers excluding Class 1, 2 and 3a lasers.
8.4 Any deviation from the acceptable performance will require an identification of the underlying pathology either with a funduscopic examination or other tests as determined to be appropriate by the responsible medical or optometric examiner.
8.5 A repeated eye exam is also required in the event of an incident that resulted in an exposure or suspected exposure to laser radiation. This examination will include the required protocols from the baseline examination and any other examinations desired by the attending physician.
8.6 An eye examination is offered when an individual terminates his or her work in a laser laboratory. This examination will include the required protocols from the baseline examination

9.0 Recordkeeping

9.1 All medical surveillance records must be maintained at the UHS for a period of no less than 5 years.
9.2 A list of all individuals approved to operate lasers must be kept by EHSO and each department.
9.3 Each department using lasers must maintain a record of all laser protective eyewear inspections. This record will be reviewed during the required laser safety surveys performed by EHSO.
9.4 Records of all laser equipment purchases, modifications, disposal and calibrations must be maintained by the department with a copy sent to EHSO review.
9.5 All laser-related incident reports must be kept including IEMA correspondence. Incident report copies are filed with EHSO, the department and Health Services.

9.6 All general laser safety and laser-specific training records must be maintained by the department with copies files at EHSO.
9.7 All laser safety committee meetings must have documented minutes filed at EHSO.
9.8 EHSO maintains records of committee and LSO appointments.
9.9 EHSO will inspect all records listed above during laser safety surveys.

10.0 Responsibility

10.1 The Vice Chancellor for Administrative Services:

- Provides the authority of the Chancellor to ensure that a Laser Safety program is maintained to protect laser safety at UIC and to ensure regulatory compliance with all applicable federal, state and local regulations.
- Provides University funding to the EHSO for a Laser Safety program.
- Advises the Chancellor and coordinates with the other Vice Chancellors on the Laser Safety program.

10.2 The Director of Environmental Health and Safety:

- Appoints the Laser Safety Officer and Deputy Laser Safety Officers.
- Ensures LSO initial and continuing education.
- Attends IEMA inspections and meetings conducted at UIC.
- Coordinates the Laser Safety Program with Associate Vice Chancellors and Deans, Directors, and Department heads of other departments.
- Ensures that the Laser Safety program is evaluated annually for compliance and successful performance.

10.3 The Laser Safety Officer:

- May not delegate the authority to approve a Laser Safety Plan but may delegate such functions as evaluations, audits, and training.
- Implements the laser safety program for IEMA compliance.
- Ensures that all individuals who operate or may be exposed to lasers receive hazard and safety practice instructions and training.
- Permits operation of only properly registered and installed laser systems with properly trained personnel.
- Ensures that all essential control measures are being followed.
- Provides expertise, recommendations and evaluations as required in the UIC laser-user community.

10.4 Laser Safety Committee:

- Reviews and provides recommendations following all laser incidents, injuries and near-miss events.
- Evaluates UIC laser safety standards.
- Meets annually or more frequently as deemed necessary by the LSO.

10.5 Deans, Directors and Department Heads:

- Register all applicable lasers purchased or received by their department through grants, endowments, credit card purchases, purchase orders or any other means.
- Ensure compliance, implementation and enforcement of this procedure within their departments.

10.6 Principal Investigators:

- Provide, implement, and enforce laser safety.
- Supervise and promote the safe use of lasers in the laboratory.
- Ensure compliance with medical surveillance for all laser operators.
- Ensure that laser operators are trained in administrative, standard of operating, and alignment procedures.
- Ensure all operators attend the initial and annual refresher UIC Laser Safety Training programs.
- Submit a completed Laser Registration Form to the LSO for all new equipment.
- Maintain proper labeling of all lasers and laser facilities within their control.
- Ensure the Department Head is informed and updated on the laboratory compliance of this procedure and any deviations from this procedure.
- **Notify the LSO immediately in the event of an exposure to a Class 3b or Class 4 laser.**

10.7 Laser Equipment Operators:

- Comply with UIC, manufacturer, and Principle Investigator LSO approved safety policies and safe laser use instruction. Instruction includes but is not limited to, approved operating, alignment, laboratory, control, and administrative procedures for operating lasers.
- Inform the Principal Investigator of any departure from established safety procedures, or approved research protocols.
- Attend the initial and annual refresher UIC Laser Safety Training programs.
- Comply with the medical surveillance program.
- Report all injuries, exposures, or unsafe conditions as soon as possible to the PI and/or the LSO.

11.0 Minority Impact Statement: This laser safety plan will have no disproportionate impact on minority faculty, students or staff at UIC.

12.0 Laser Classifications

12.1 The following provide standard definitions of laser Classification. Further information on laser classification regulations may be supplied by request from the Environmental Health and Safety Office or the Laser Safety Officer at (312)-413-3706.

12..2 Federal Laser Product Performance Standard (FLPPS) Classifications

12..2.1 Class 1 means any laser product that does not permit access during the operation to damaging levels of laser radiation. Class 1 levels of laser radiation are not considered to be hazardous.
12..2.2 Class 2 radiation levels are considered to be a chronic viewing hazard.
12..2.3 Class 2 means any laser that permits human access during operation to visible laser radiation, but does not permit human access during operation to levels of laser radiation in excess of 1mW. Eye protection is normally provided by the aversion response to bright light, including the blink reflex. Class 2 levels of laser radiation are considered to be a chronic viewing hazard. Class 2a levels of laser radiation are not considered to be hazardous if viewed for any period of time less than or equal to 1 x 10 3 seconds but are considered to be a chronic viewing hazard for any period of time greater than 1 x 103 seconds. Output power is less than 1mW.
12..2.4 Class 3 laser product means any Class 3a or Class 3b laser product.
12..2.5 Class 3a levels of laser radiation are considered to be hazardous depending upon the irradiance. The hazard for unaided viewing will be either an acute intra-beam or chronic viewing hazard. If viewed directly with optical instruments this becomes an acute viewing hazard.
12..2.6 Class 3b levels of laser radiation are considered to be an acute hazard to the skin and eyes from direct radiation. Normally Class 3b lasers will not produce a hazardous diffuse reflection from a matte surface or target.
12..2.7 Class 4 laser radiation from direct, specular, and/or diffuse reflections may cause acute eye and/or skin hazards. Direct beam Class 4 lasers may create a fire hazard when the directed beam has not been properly reduced in power or energy, placed in a stand-by mode or properly absorbed.
12..2.8 The use of Class 3b or Class 4 lasers as part of an enclosed (embedded) system where a protective cover provides an engineering control to reduce hazard may be classified as a certified Class 1 laser. Removal of this control, (protective cover), reverts the laser to an open Class 3b or 4 laser requiring strict compliance to this policy.

12.3 International Electrotechnical Commission IEC 60825-1.2 – 2001, IEC 60825-.1-998, definitions.

12.3.1 All current Class 1 are Class 1 and Class 1M 5.3.1.1. Class 1 lasers are true "EYE SAFE" laser products, safe under every conceivable condition of use.

12.3.1.1 Class 1M lasers are "EYE SAFE" for the unaided eye with no added optical elements under every reasonably foreseeable viewing condition.
12.3.1.2 Class 1M lasers should not be viewed with optical aids such as hand-held magnifiers and microscopes, binoculars and telescopes.

12.3.2 Most current Class 2 lasers are Class 2 or 2M if a highly divergent beam such as a diode laser is present.
12.3.3 All current ANSI Class 3a "Danger" laser pointers are Class 3R. Class 3B is the same as the ANSI Class 3b but does not include the old ANSI

Class 3a, non-expanded-beam lasers, displaying a "danger" label. Class 4 lasers or laser products remain the same.

12.4 Classification is made by the manufacturer according to the capability for the laser beam to cause injury and not from any non-beam hazards that may also be present.

12.5 Classification should be on the laser nameplate when purchased from a manufacturer in compliance with FDA manufacturing requirements.

13.0 References:

- 32 Illinois Administrative Code - Chapter II, Subchapter B, Part 315 Standards for Protection Against Laser Radiation, August 2001.
- 420 Illinois LCS 56 Laser System Act of 1997.
- American National Standard for Safety Use of Lasers ANSI Z136.1 – 2007.
- American National Standard for the Safe Use of Optical Fiber Communication Systems Utilizing Laser Diode and LED Source, ANSI Z136.2 – 1997.
- American National Standard for Safe Use of Lasers in Health Care Facilities, ANSI Z136.3 - 1996.
- American National Standard for Safe Use of Lasers in Educational Institutions, ANSI Z136.5 - 2000.
- Food, Drug and Cosmetic Act, Medical Device Amendment.
- International Electrotechnical Commission IEC 60825-1.2 - 2001. as EN60825 in Europe.
- Laser Safety Institute, http-//www.laserinstitute.org.
- Public Law 90-602 Radiation Control for Health and Safety Act of 1968 (RCHSA).
- DHHS, Department of Health and Human Services, National Institute of Occupational Safety and Health, DHHS (NIOSH) Publication No. 96-128, Hazard Control 11. Control of Smoke From Laser/Electric Surgical Procedures.
- US Department of Health and Human Services, US Food and Drug Administration, 21 Code of Federal Regulations Subchapter J, Federal Laser Product Performance Standard (FLPPS) 29 CFR Part 100.
- US Department of Health and Human Services, US Food and Drug Administration, HHS News P97-45, December 18, 1997. FDA Issues Warning on Misuse of Laser Pointers.
- U.S. Department of Health and Human Services, US Food and Drug Administration, 21 Code of Federal Regulations Vol. 8 1040.10 Performance Standards for Light-Emitting Products.
- U.S. Department of Labor, Occupational Safety & Health Administration, OSHA Directive Number- PUB 8-1.7 August 5, 1991 Guidelines for Laser Safety and Hazard Assessment.
- Center for Devices and Radiological Health (CDRH)
- Title 49 of the U.S. Code (49 U.S.C.), Section 40103 gives the Administrator the authority to regulate, control, develop plans for, and formulate policies with respect to the use of the navigable airspace.
- Regulatory authority for laser light products has been delegated to the Food and Drug Administration (FDA). Product regulations are detailed in 21 CFR, part 1010, Performance Standards for Electronic Products, and part 1040, Performance Standards for Light Emitting Products.

Appendix A - Reference Tables

Table 2 Control Measures for the Laser Classes

Engineering Control Measures	Classification					
	1	2a	2	3a	3b	4
Protective Housing(5.3.1)	X	X	X	X	X	X
Without Protective Housing(5.3.1.1)	LSO establishes alternate controls					
Interlocks on Protective Housing(5.3.2)	%	%	%	%	X	X
Service Access Panel(5.3.3)	%	%	%	%	X	X
Key Control(5.3.4)	--	--	--	--	*	X
Viewing Portals(5.3.5.1)	--	--	MPE	MPE	MPE	MPE
Collecting Optics(5.3.5.2)	MPE	--	MPE	MPE	MPE	MPE
Totally Open Beam Path(5.3.6.1)	--	--	--	--	X,NHZ	X,NHZ
Limited Open Beam Path(5.3.6.2)	--	--	--	--	X,NHZ	X,NHZ
Enclosed Beam Path(5.3.6.3)	None is required if 4.3.1 and 4.3.2 are fulfilled					
Remote Interlock Connector(5.3.7)	--	--	--	--	*	X
Beam Stop or Attenuator(5.3.8)	--	--	--	--	*	X
Beam Stop or Attenuator(5.3.8)	--	--	--	--	*	X
Activation Warning Systems(5.3.9)	--	--	--	--	*	X
Emission Delay(5.3.9)	--	--	--	--	--	X
Indoor Laser Controlled Area(5.3.10)	--	--	--	--	X,NHZ	X,NHZ
Class 3b Laser Controlled Area(5.3.10.1)	--	--	--	--	X	--
Class 4 Laser Controlled	--	--	--	--	--	X

Area(5.3.10.2)						
Laser Outdoor Controls(5.3.11.1)	--	--	--	--	X,NHZ	X,NHZ
Laser in Navigable Airspace(5.3.11.2)	--	--	--	*	*	*
Temporary Laser Controlled Area(5.3.12)	%,MPE	%,MPE	%,MPE	%,MPE	--	--
Remote Firing & Monitoring(5.3.13)	--	--	--	--	--	--
Labels(5.3.14 and 5.7)	X	X	X	X	X	X
Area Posting(5.3.15)	--	--	--	*	X,NHZ	X,NHZ
Administrative Control Measures						
Standard Operating Procedures(5.4.1)	--	--	--	--	*	X
Output Emission Limitations(5.4.2)	--	--	--	LSO Determination		
Education and Training(5.4.3)	--	--	*	*	X	X
Authorized Personnel(5.4.4)	--	--	--	--	X	X
Alignment Procedures(5.4.5)	--	--	X	X	X	X
Protective Equipment(5.4.6)	--	--	--	--	*	X
Spectator(5.4.7)	--	--	--	--	*	X
Warning Signs and Labels(5.7)	--	--	*	*	X,NHZ	X,NHZ
Service Personnel(5.4.8)	%,MPE	%,MPE	%,MPE	%,MPE	X	X
Demonstration with General Public(5.5.1)	MPE,+	--	X	X	X	X
Laser Optical Fiber Systems(5.5.2)	MPE	MPE	MPE	MPE	X	X
Laser Robotic Installations(5.5.3)	--	--	--	--	X,NHZ	X,NHZ

Personal Protective Equipment						
Eye Protection(5.6.2)	--	--	--	--	*,MPE	X,MPE
Protective Windows(5.6.3)	--	--	--	--	X,NHZ	X,NHZ
Protective Barriers and Curtains(5.6.4)	--	--	--	--	*	*
Skin Protection(5.6.5)	--	--	--	--	X,MPE	X,MPE
Other Protective Equipment(5.6.5)	Use may be required					
Service and Repairs(5.8)	LSO Determination					
Modification of Laser Systems	LSO Determination					

LEGEND	X	Shall
	*	Should
	--	No requirements
	%	Shall if enclosed Class 3b or Class 4
	MPE	Shall if MPE is exceeded
	NHZ	Nominal Hazard Zone analysis required
	+	Applicable only to UV and IR lasers
	LSO	Laser Safety Officer

from ANSI Z.136.1-2000

IEMA 315 Table A MPE for Ocular Exposure (Intrabeam Viewing)

Ultraviolet			
Wavelength (Mu m)	Exposure Duration, t (s)	MPE	
		(J/cm^2)	(W/cm^2)
0.180 to 0.302	10(-9) to 3 x 10(4)	3 x 10(-3)	
0.303	10(-9) to 3 x 10(4)	4 x 10(-3)	
0.304	10(-9) to 3 x 10(4)	6 x 10(-3)	
0.305	10(-9) to 3 x 10(4)	10 x 10(-3)	
0.306	10(-9) to 3 x 10(4)	16 x 10(-3)	
0.307	10(-9) to 3 x 10(4)	25 x 10(-3)	
0.308	10(-9) to 3 x 10(4)	40 x 10(-3)	
0.309	10(-9) to 3 x 10(4)	63 x 10(-3)	
0.310	10(-9) to 3 x 10(4)	0.1	
0.311	10(-9) to 3 x 10(4)	0.16	
0.312	10(-9) to 3 x 10(4)	0.25	
0.313	10(-9) to 3 x 10(4)	0.40	
0.314	10(-9) to 3 x 10(4)	0.63	
0.315 to 0.400	10(-9) to 10	0.56 *t*(1/4)	
0.315 to 0.400	10 x 3 x 10(4)	1.0	

NOTE:
To calculate MPE, use the J cm(-2) value shown or 0.56 *t*(1/4), whichever is lower.

Visable and Near Infrared

Wavelength (Mu m)	Exposure Duration, t (s)	MPE	
		(J/cm^2)	(W/cm^2)
0.400 to 0.700	10(-9) to 18 x 10(-6)	0.5 x 10(-6)	
0.400 to 0.700	18 x 10(-6) to 10	1.8 *t*(3/4) x 10(-3)	
0.400 to 0.550	10 to 10(4)	10 x 10(-3)	
0.550 to 0.700	10 to T[1]	1.8 *t*(3/4) x 10(-3)	
0.550 to 0.700	T[1] to 10(4)	10C[B]to 10(-3)	
0.400 to 0.700	10(4) to 3 x 10(4)		C[B] x 10(-6)
0.700 to 1.050	10(-9) to 18 x 10(-6)	0.5C[A] x 10(-6)	
0.700 to 1.050	18 x 10(-6) to 10(3)	1.8C[A] *t*(3/4) x 10(-3)	
0.700 to 1.050	10(3) to 3 x 10(4)		320C[A] x 10(-6)
1.050 to 1.400	10(-9) to 50 x 10(-6)	5C[c] x 10(-6)	
1.050 to 1.400	50 x 10(-6) to 10(3)	9.0C[c] *t*(3/4) x 10(-3)	
1.050 to 1.400	10(3) to 3 x 10(4)		1.6C[c] x 10(-3)

NOTES:

1. See Section 315.Tables D & E for limiting apertures (see ANSI Z136.1 pg. 44).
2. For multiple pulses, apply correction factor C[p] given in Section 315.Table C.
3. For information on correction factors T(1), C[B], C[A], C[p] and C[e], see Section 315.Table C.

Far Infrared

Wavelength (Mu m)	Exposure Duration, t (s)	MPE	
		(J/cm^2)	(W/cm^2)
1.400 to 1.500	10(-9) to 10(-3)	0.1	
1.400 to 1.500	10(-3) to 10	0.56 *t*(1/4)	
1.400 to 1.500	10 to 3 x 10(4)		0.1
1.500 to 1.800	10(-9) to 10	1.0	
1.500 to 1.800	10 to 3 x 10(4)		0.1
1.800 to 2.600	10(-9) to 10(-3)	0.1	
1.800 to 2.600	10(-3) to 10	0.56 *t*(1/4)	
1.800 to 2.600	10 to 3 x 10(4)		0.1
2.600 to 10(3)	10(-9) to 10(-7)	10 x 10(-3)	

2.600 to 10(3)	10(-7) to 10	0.56 *t*(1/4)	
2.600 to 10(3)	10 to 3 x 10(4)		0.1

Notes:

1. See Section 325.Tables D & E for limiting apertures (see ANSI Z136.1 pg. 44).
2. For multiple pulses, apply correction factor C[p] given in Section 315.Table C.

General Notes:

1. The MPE for diffuse reflections at wavelengths between 0.400 and 1.400 Mu m is obtained by multiplying the corresponding MPEs above by C[E] (see Section 315.Table C for correction factors and T[1]).
2. For repeated (pulsed) exposures, see ANSI Z136.1.
3. For purposes of this Section 315.Table A, the following abbreviations or symbols are used:

   Mu m = micrometers
   t(s) = time in seconds
   J = joules
   W = watts
   cm = centimeters

IEMA Section 315.Table B MPE for Skin Exposure

Ultraviolet			
Wavelength (Mu m)	Exposure Duration, t (s)	MPE	
		(J/cm^2)	(W/cm^2)
0.180 to 0.302	10(-9) to 3 x 10(4)	3 x 10(-3)	
0.303	10(-9) to 3 x 10(4)	4 x 10(-3)	
0.304	10(-9) to 3 x 10(4)	6 x 10(-3)	
0.305	10(-9) to 3 x 10(4)	1.0 x 10(-2)	
0.306	10(-9) to 3 x 10(4)	1.6 x 10(-2)	
0.307	10(-9) to 3 x 10(4)	2.5 x 10(-2)	
0.308	10(-9) to 3 x 10(4)	4.0 x 10(-2)	
0.309	10(-9) to 3 x 10(4)	6.3 x 10(-2)	
0.310	10(-9) to 3 x 10(4)	1.0 x 10(-1)	
0.311	10(-9) to 3 x 10(4)	1.6 x 10(-1)	
0.312	10(-9) to 3 x 10(4)	2.5 x 10(-1)	
0.313	10(-9) to 3 x 10(4)	4.0 x 10(-1)	
0.314	10(-9) to 3 x 10(4)	6.3 x 10(-1)	
0.315 to 0.400	10(-9) to 10	0.56 *t*(1/4)	
0.315 to 0.400	10 x 10(3)	1	
0.315 to 0.400	10(3) to 3 x 10(4)		1 x 10(-3)

NOTES: To calculate MPE, use the J/cm^2 value shown or 0.56 *t*(1/4), whichever is lower.

1. 3.5 mm limiting aperture (see Section 315.Table D).

Visible and Near Infrared			
Wavelength (Mu m)	Exposure Duration, *t* (s)	MPE	
		(J/cm^2)	(W/cm^2)
0.400 to 1.400	10(-9) to 10(-7)	2C[A] x 10(-2)	
	10(-7) to 10	1.1C[A] *t*(1/4)	
	10 to 3 x 10(4)		0.2C[A]

NOTES:

1. 3.5 mm limiting aperture (see Section 315.Table D).

Far Infrared			
Wavelength (Mu m)	Exposure Duration, *t* (s)	MPE	
		(J/cm^2)	(W/cm^2)
1.400 to 10(3)	10(-9) to 10(-7)	10(-2)	
	10(-7) to 10	0.56 *t*(1/4)	
	>10		0.1

NOTE:

See Section 315.Table D for limiting apertures.

NOTE: For purposes of this Table, the following abbreviations or symbols are used:

Mu m = micrometers
t(s) = time in seconds
J = joules
W = watts
cm = centimeters
mm = millimeters

Section 315.Table C Parameters and Correction Factors

Correction Factor	Wavelength (Mu m)
T[1] = 10 x 10 (20)(Lambda-0.550)	0.550 to 0.700
C[B] = 1.0	0.400 to 0.500
C[B] = 10 (15)(Lambda-0.550)	0.550 to 0.700
C [A] = 1.0	0.400 to 0.700
C [A] = 10(2)(Lambda-0.700)	0.700 to 1.050
C [A] = 5.0	1.050 to 1.400
C[p] = n(-14)	0.400 to 1000
C[E] = 1.0 Alpha < Alpha [min]	0.400 to 1.400
C[E] = Alpha/ Alpha [min] Where: Alpha [min] < Alpha < Alpha [max]	0.400 to 1.400
C[E] = Alpha(2) / (Alpha [max] x Alpha [min]) Where: Alpha > Alpha [max]	0.400 to 1.400
C[c] = 1.0	1.050 to 1.150
C[c] = 10 (18)(Lambda-1.150)	1.150 to 1.200
C[c] = 8	1.200 to 1.400

NOTES:
1. For pulse repetition frequencies below 55 kHz (0.4 to 1.05 Mu m) and below 20 kHz (1.05 to 1.4 Mu m) see ANSI Z136.1.
2. For wavelengths between 0.400 and 1.400 Mu m:
   Alpha [min] = 1.5 mrad for *t* less than or equal to 0.7 s
   Alpha [min] = 2 *t*(3/4) mrad for 0.7 s < *t* < 10 s
   Alpha [min] = 11 mrad for *t* greater than or equal to 10 s
   Alpha [max] = 100 mrad
3. For purposes of this Section 315.Table C, the following abbreviations or symbols are used:

Lambda = wavelength in Mu m	n = number of pulses
Alpha = angular subtense (mrad)	*t* = time
t(s) = time in seconds	s = seconds
Mu m = micrometers	Min = minimum
Max = maximum	mrads = milliradiums
kHz = kilohertz	

Section 315.Table D Limiting Apertures for Hazards Evaluation and AEL Determination

Spectural Region (Mu m)	Duration (s)	Aperture Diameter (mm)	
		Eye	Skin
0.180 to 0.400	10(-9) to 0.25	1.0	3.5
	0.25 to 3 x 10(4)	3.5	3.5
0.400 to 1.400	10(-9) to 3 x 10(4)	7.0	3.5
1.400 to 10(2)	10(-9) to 0.3	1.0	3.5
	0.3 to 10	1.5 *t*(3/8)	3.5
	10 to 3 x 10(4)	3.5	3.5
10(2) to 10(3)	10(-9) to 3 x 10(4)	11.0	11.0

NOTES:

1. Under normal conditions these exposure durations would not be used for hazard evaluation, see ANSI Z136.1 (Table 8).
2. For purposes of this Section 315.Table D, the following abbreviations or symbols are used:

Mu m = micrometers
s = seconds
mm = millimeters
t(s) = time in seconds

Section 315.Table E Measurement Apertures for Classification

Spectural Region (Mu m)	Duration (s)	Aperture Diameter (mm)
0.180 to 0.302	10(-9) to 0.25	1.0
	0.25 to 3 x 10(4)	3.5
0.302 to 2.8	10(-9) to 3 x 10(4)	50.0
2.8 to 10(2)	10(-9) to 0.3	1.0
	0.3 to 10	1.5 *t*(3/8)
	10 to 3 x 10(4)	3.5
10(2) to 10(3)	10(-9) to 3 x 10(4)	11.0

NOTES:

1. These apertures are used for the measurement of optical power or energy for purposes of laser classification.
2. When the laser output is intended to be viewed with optics (excluding ordinary eyeglasses) or the laser safety officer determines that there is reasonable probability of accidental viewing with optics, a 50 mm aperture is used if the following conditions are met:
   A. Viewing with optics presents a more severe hazard than unaided viewing.
   B. The viewing time is sufficient to constitute a hazard.
3. Under normal conditions these exposure durations would not be used for classification.
   (see ANSI Z136.1 (Table 9)).
4. For purposes of this Section 315.Table E, the following abbreviations or symbols are used:

   Mu m = micrometers
   s = seconds
   mm = millimeters
   t(s) = time in seconds

Accessible Emission Limits for Continuous-Wave Small-Source Lasers and Laser Systems

Wavelength Range (μm)	Emission Duration (s)	Class 1 (W)	Class 2 (W)	Class 3 (W)	Class 3a (W)	Class 4 (W)
Ultraviolet						
0.18-0.302	3×10^{4}	$\leq 9.6 \times 10^{-9}$	----	>Class 1 but	1-5x Class 1	>0.5
0.302-0.4	3×10^{4}	$\leq 3.2 \times 10^{-6}$ Depending on wavelength		≤0.5		>0.5
Visible						
0.4-0.7	10	$\leq 0.4 \times 10^{-3}$	>Class 1 but $\leq 1 \times 10^{-3}$	>Class 2 but ≤0.5	<5xClass 2	>0.5
Near Infrared						
0.7-1.05	>10	$\leq 0.4 \times 10^{-3}$ to $\leq 1.9 \times 10^{-3}$		>Class 1 but≤0.5		>0.5
1.05-1.15	>10	$\leq 1.9 \times 10^{-3}$		>Class 1 but≤0.5		>0.5
1.15-1.2	>10	$\leq 1.9 \times 10^{-3}$ to 1.5×10^{-2}				
1.2-1.4	>10	$\leq 1.5 \times 10^{-2}$				
Far Infrared						
1.4-100	>10	$\leq 9.6 \times 10^{-3}$		>Class 1 but≤0.5		>0.5
Submillimeter						
102-103	>10	$\leq 9.5 \times 10^{-2}$		>Class 1 but≤0.5		>0.5

Adapted from ANSI Z136.1-2000

Appendix B - Basic Laser Safety Concepts

What is a Laser?
Laser is an acronym for Light Amplification by Stimulated Emission of Radiation. In this situation, the "radiation" is a non-ionizing light beam in the ultraviolet, visible, or infrared portions of the electromagnetic spectrum. Laser light beam waves all have the same frequency or time. In addition, they are all in the same phase, known as coherency. As a result, laser beams have almost no divergence. They have a high concentration of energy or power density at both ends of the beam, creating a significant hazard potential at considerable distance. Unlike ionizing radiation, lasers radiation is only hazardous when it is on and when you have line-of-sight to the beam or a reflection of the beam.

Lasers are used commercially for such things as CD players, scanners, and laser copiers. Industrial applications include laser welding, cutting and marking. Medical lasers are used in many surgical procedures such as photocoagulation and ablation. The military uses laser beams for range-finding, target tracking, and training. In research, the laser is used to study thin layers, in spectroscopy and for molecule detection.

A laser has three basic parts:
The high-Q optical cavity or resonator contains mirrors specifically designed to transmit laser beams. An active medium such as solid crystalline material, gas, liquid dye or semiconductor material which absorbs energy from an external source and produces laser light through atomic processes. The excitation mechanism or energy pump is the external energy source. It can be light, as in solid lasers, electric current passing through semiconductor lasers, or chemical reaction energy. The energy excites the atoms to attain a population inversion. As the atoms fall back into their ground state, they release this energy to emit photons.

Lasers are operated in different modes. These are the continuous wave, pulsed, and Q-switched. A common continuous wave laser is the CO2 laser. The ruby laser is an example of a pulsed mode with bursts of light from about 1/30 to 10 pulses per second. The Q-switched laser has a device like a shutter so that high energies are accumulated before the beam is produced, resulting in a very high power, narrow beam width.

What are the potential biological effects from lasers?
Biological effects of laser beams create hazard risks to the eye and the skin based on the wavelength and the tissue being exposed. The cornea, or "window" clear covering of the eye is susceptible to photokeratitis (welder's flash) from exposure to ultraviolet radiation, with a peak of action spectrum of 270 nm. It can also receive thermal burns from infrared B and C radiation. If burns are deep, permanent opacity may result, requiring a corneal transplant. The lens of the eye, just under the eye "color" shutter or pupil, can become opaque or clouded. This is known as a cataract. It can be caused by ultraviolet light at 300 nm or infrared heat (once common with glass blowers.) The lens takes an image and condenses or focuses it on the back of the eye on a membrane called the retina. This focus process is called optical gain because it increases the image intensity. Laser light in the visible range can cause retinal burns, permanent blind spots, and retinal hemorrhage with vision loss. It is important to realize that reflected laser beams can create the same hazards depending on what fraction of the light is reflected. A reflection coefficient for certain materials is used by the Laser Safety Officer to calculate the maximum safe brightness and eye protection needs. Skin may be injured by thermal burns with high exposure, ultraviolet sunburn erythema and delayed effects from ultraviolet radiation, such as skin cancer and accelerated skin aging.

What are some of the safety measures for using lasers?
Laser safety eye protection must take into consideration the wavelength, the attenuation at that wavelength, comfort and fit, training, inspection and storage. Each laser beam wavelength requires a specific lens or Optical Density. The goggles or glasses must be marked with the OD at the frequencies for which it is approved. Laser eyewear should never be used for direct viewing of a laser beam. It is for diffuse viewing only. Laser curtains and barriers can be used to enclose a controlled area. Skin may require personal protective clothing. The Principal Investigator, with the consultation of the laser manufacturer and the Laser Safety Officer, can identify the correct eye and skin protection necessary for safe laser operation. This information should be contained in the Standard Operating Procedure required for each specific laser unit.

In addition to beam-related hazards, there are sometimes non-beam hazards. These may include loud noise, chemical exposures, fumes or laser generated air contaminants, biological agents, high energy electricity (especially in capacitors), fires, cryogenics, compressed gas pressures and other safety hazards. The EHSO provides evaluation and recommendations for protection against these hazards. The SOP for the laser unit is required to provide this information as well. State and federal regulations provide threshold exposure limits beyond which exposure to laser hazards with various types of lasers are not permitted. Several associations such as ANSI and the American Conference of Governmental Industrial Hygienists also provide exposure limit recommendations.

Where can I find more information about lasers and laser safety?

1. From the UIC Environmental Health and Safety Office at 996-7411, or in an emergency or no answer, 996-SAFE (996-7233).
2. From the EHSO Laser Safety Officer 413-3706 or Deputy Safety Officers 413-3705, 996-7429.
3. From the Illinois Department of Nuclear Safety at http://www.idns.gov.
4. From the Occupat5ional Health and Safety Administration OSHA Publication 8-1.7 *Guidelines for Laser Safety and Hazard Assessment* at http://www.slc.-.osha.gov.
5. See References listed in Section 3.0 of this Program for Laser Safety Protection.
6. Bulletin prepared by the Laser Institute of America's Laser Safety Committee to educate new laser users on the concerns and issues related to laser safety, LIA Laser Safety Information Bulletin
7. Information sheet on the safe use of laser pointers prepared by the UK's National Radiation Protection Board, Laser Pointers
8. Informative article from the Vancouver Hospital & Health Sciences Centre on the effects of laser energy on the eye, Laser Safety and the Eye: Hidden Hazards and Practical Pearls
9. Comprehensive guidance from the CCOHS on the safe use of lasers in health care facilities OSH Answers: Lasers in Health Care
10. Online tutorial provided by the University of Illinois for users of laser systems who have not had previous laser safety training UIUC Laser Safety Training Tutorial

This brief discussion is a general overview of lasers and is not to be used or regarded as a a substitute for initial or annual laser training as required in UIC policy and by the Illinois Administrative Code Title32: Energy, Chapter II: Division of Nuclear Safety Subchapter b., Radiation Protection, Part 315, Standards for Protection Against Laser Radiation
Call EHSO at 996-7411 for training schedule information and registration.

Appendix C - Laser Safety Formulas

Nominal Hazard Zone – Intra-beam

$$r_{NHz} = \frac{1}{\phi}\left[\left(\frac{4\Phi}{\pi EL}\right) - a^2\right]^{\frac{1}{2}}$$

Nominal Hazard Zone - Lens on Laser

$$r_{NHz} = \left(\frac{f_o}{b_o}\right)\left(\frac{4\Phi}{\pi EL}\right)^{\frac{1}{2}}$$

Optical Density

$$O.D._{needed} = \log\left[\frac{ML}{EL}\right]$$

Appendix D - IEMA Sample Standard Operating Procedures

Standard Operating Procedures (SOPs) are governed by institutional policy and are developed, modified and maintained in accordance with the needs of individual facilities. Information relative to safety incorporated into these SOPs is gathered from a wide range of resources, including, but not limited to, the laser system manufacturer or distributor. This appendix contains examples of SOPs for issues associated with the use of laser systems. It is recognized that the safety needs of installations with multiple laser systems may be different from those facilities with a single laser system. The samples that follow cannot cover all situations or procedures; they are only intended as models that should be used to accommodate specific requirements. Typically, the Laser Safety Officer shall have the responsibility to see that SOPs are followed.

It is reasonable to expect that the manufacturer of the laser system shall supply safety information that can serve as the cornerstone for the generation of the SOPs. It is incumbent upon the operator to demand the information from the manufacturer. The availability of safety related information is facilitated by the FDA requirement that the manufacturer of laser products provide the user with adequate instructions for the safe operation and maintenance of all laser products.

SAMPLE 1: Controlled Access to the Laser Room

Purpose: To define the area in which control measures shall be applied and to describe the control measures necessary in order to maintain a safe environment for use of the laser system.

Policy: Class 3b and Class 4 lasers shall be operated in areas where traffic flow and compliance with all safety procedures can be monitored.

Procedure:

1) Appropriate warning signs shall be posted at eye level on all doors that access a room where a laser is to be operated. These signs shall state all required information and shall be removed when the laser is not in use.

2) Safety goggles labeled with the appropriate wavelength and optical density shall be available at the entry where each door sign is posted.

3) Glass windows shall be covered with shades or filters of appropriate optical density whenever a fiber-optic laser system is operational.

4) All safety procedures shall be followed during service, maintenance and demonstrations.

5) No one shall be allowed into a laser room unless properly authorized and protected.

6) The laser shall not be activated when it is necessary to open the door, if the controlled area extends to the doorway.

7) Laser keys shall be kept in a secured area and signed out only by authorized persons.

SAMPLE 2: Ocular Safety

Purpose: To prevent ocular injuries to personnel working with Class 3b and Class 4 lasers.

Policy: Within the controlled area, all personnel shall adhere to appropriate eye protection procedures during all laser applications.

NOTE: Under some conditions, the controlled area may include the entire room in which the laser procedure is performed. Under those conditions, the ocular safety procedures listed in this Sample 2 apply to the entire room. In health care facilities, ocular safety procedures shall also apply to the patient receiving laser treatment.

All personnel involved in maintenance and demonstrations of laser systems shall follow all ocular safety procedures whenever a laser is in operation in the facility.

Procedure:

1) Appropriate eyewear shall be worn by everyone in the controlled area while the laser is in operation. Appropriate eyewear consists of glasses or goggles of sufficient optical density to prevent ocular damage at the laser wavelength in use. Exception to this is the operator looking through an attached microscope with a lens that has the appropriate optical density for the laser in use.

2) Prior to use, the operator and ancillary personnel shall be responsible for selecting and examining eyewear for comfort, proper fit, and presence of labels describing both wavelength and proper optical density.

3) If eyewear is damaged, it shall not be worn and a report shall be made to the laser safety officer.

4) Contact lenses are not acceptable as protective eyewear. Prescription lens wearers shall use appropriate laser safety eyewear.

5) All goggles shall have side shields to protect from peripheral injury and impact.

6) Any articulated arm that is not shuttered shall be capped when not connected to the hand piece or the operating microscope.

7) The laser system shall be placed in standby mode when delivery optics are moved away from the target.

8) In health care facilities, patients shall be fitted with appropriately labeled eyewear, or have their eyes covered with wet cloth pads or towels. Metal or dry materials shall be placed on the patient's face or eyes only when indicated.

SAMPLE 3: Handling of Laser Fiber Delivery Systems in Health Care Facilities

Purpose: To promote safe and proper handling of laser fiber delivery systems and to limit the potential for fiber breakage, damage and reduced efficiency during clinical laser procedures.

Policy: Personnel handling laser fibers shall assure compliance with all safety procedures and shall consider the fiber an extension of the laser system, governed by applicable standards and regulations.

Procedure:

1) Appropriate eye safety filters shall be used with endoscopes.

2) Laser room windows shall be covered completely with appropriate filters, if necessary.

3) Fibers and associated equipment shall be positioned to allow for safe traffic patterns in the room.

4) The fiber shall be examined for breaks or damage of the distal tip, the proximal connector and the catheter sheath. Fiber shall be calibrated in accordance with manufacturer's directions. If deficiencies or damage are noted, another fiber shall be obtained.

5) Do not use clamps or other instruments to secure fiber in the operative site.

6) Always use coaxial cooling that is appropriate to the procedure. Never use gas to purge a fiber in the intrauterine cavity.

7) Never operate the laser unless the aiming beam (if used) and the tip of the fiber beyond the end of the endoscope are both visible.

8) Monitor the fiber for distortion of the beam, decreased power transmission and accumulation of debris on the tip.

9) Never reuse a disposable fiber without manufacturer's directions.

10) Always put the laser in standby when not aimed at a target.

SAMPLE 4: Non-Beam Hazards in Health Care Facilities

Purpose: To recognize and effectively deal with a variety of potential non-beam hazards that may be present during laser procedures.

Policy: Non-beam hazards are the purview of safety and industrial hygiene personnel, who will effect the appropriate hazard evaluation and control.

Procedure:

I. Fire

1) Never use alcohol in the operative field. Fibers may be rinsed in hydrogen peroxide or saline intra-operatively.

2) Never place a hot fiber directly on paper drapes. Wait until tip is cool before contact is made with flammable material.

3) Use fire-retardant drapes, damp packs or pads. Fill pelvic cavity with Ringer's, saline or other appropriate solution during surgery.

4) Put laser system in standby mode when procedure is interrupted or terminated.

5) Avoid high levels of oxygen in the operative field.

6) Avoid laser beam exposure of the sheaths of flexible fiber endoscopes, since many of the sheaths are flammable.

II. Plume Management

1) Remove laser generated airborne contaminants from the laser target area to reduce the transmission of potentially hazardous particles.

2) Position smoke evacuator in the operating room whenever a plume is anticipated.

3) Check operation of the plume management system prior to the beginning of a procedure.

4) Check the plume filter monitor and, if needed, install a clean filter.

5) In-line filters with minimum 0.3 Mu m (micrometers) filtration shall be placed between wall suction and the fluid cannister for:

a) Suction lines not connected to evacuator

b) Procedures producing minimal plume

c) Failure of evacuator before or during operation

6) Distal collection port shall be no more than 2 cm from impact site when practical.

7) All tubing, connectors, adaptors and wands will be changed between patients and disposed of according to biohazard procedures.

III. Electrical Shock

1) During service or maintenance, precautions shall be taken against electrical shock that may be fatal.

2) Medical lasers shall be installed and operated in conformity with the National Electrical Code.

SAMPLE 5: Work Practices for Optical Fiber Communications Systems (OFCS)

Purpose: To recognize and effectively deal with a variety of potential hazards that may be present when working on an OFCS.

Policy: Engineering controls shall not take the place of good work practices. Good work practices are essential to operating, servicing and maintaining OFCS, especially with higher power systems that utilize Class 3b and Class 4 lasers.

Procedure: The following presents some basic guidelines when working on any OFCS.

1) Trained Personnel. Only authorized, trained personnel shall be permitted to install or perform service on OFCS containing Class 3b or Class 4 lasers.

2) Unterminated Fibers:

   a) Do not view the end of a fiber with unprotected eyes. Fiber should only be viewed with an indirect image converter or with a filtered optical instrument or optical density (OD) sufficient to reduce the exposure to levels below the appropriate MPE.

   b) Always cover the ends of unterminated fibers with a splice protector, tape or end caps.

3) Splicing arrays and cables:

   Splicing of ribbon cables, fixed array cables or OFCS containing Class 3b or Class 4 lasers shall be performed only when the OFCS or cables are de-energized. Personal protection equipment such as protective eyewear or viewing systems, (cameras or microscopes) that incorporate appropriate optical density filters shall be used. Refer to 2 a) above.

4) Installation and testing:

   When installing an OFCS, the laser source shall be first to be disconnected and last to be connected.

5) Modifications:

   No modifications shall be made to the OFCS or associated equipment without management or supervision authorizations. Such modifications may alter the service group classification of the OFCS.

6) Labels:

   Any damaged or missing optical safety labels shall be reported immediately to the supervisor.

7) Other Hazards

a) Use of protective guards or shields shall be used during splicing and cleaving operation to prevent direct injury from small lengths or particles of fiber. Proper disposal of fiber pieces avoids subsequent embedding in clothing or skin.

b) Optical photo-curing may present a UV or light source hazard. Protective filter lenses of the appropriate optical density shall be worn if viewing of the light source is probable.

Appendix E - IEMA Labeling and Warning Sign Requirements and Samples

Section 315.150 Caution Signs, Labels and Postings

a) Except as otherwise authorized by the Department, signs and labels prescribed by this Section shall use the design and colors specified in Illustration A and B below.

b) Controlled areas shall be conspicuously posted with appropriate sign or signs as specified in subsection (c) of this Section.

c) Labeling and Posting Laser Systems and Laser Facilities

1) Class 3b lasers shall have a label and facilities shall be posted with signs with the warning specified in Illustration A below and including the following wording:

(Position 1 on the logotype)

"LASER RADIATION - AVOID DIRECT EXPOSURE TO BEAM"

(Position 3 on the logotype)

"CLASS 3b LASER"

2) Class 4 lasers shall have a label and facilities shall be posted with signs with the warning specified in Illustration B below and including the following wording:

(Position 1 on the logotype)

"LASER RADIATION-AVOID EYE OR SKIN EXPOSURE TO

DIRECT OR SCATTERED RADIATION"

(Position 3 on the logotype)

"CLASS 4 LASER"

3) Each laser, except lasers used in the practice of medicine, shall have labels in close proximity to each aperture through which is emitted accessible laser radiation in excess of the MPE with the following wording as applicable:

A) "AVOID EXPOSURE- Laser radiation is emitted from this aperture", if the radiation emitted through such aperture is laser radiation.

B) "AVOID EXPOSURE- Hazardous electromagnetic radiation is emitted from this aperture", if the radiation emitted through such aperture is electromagnetic radiation.

C) "AVOID EXPOSURE- Hazardous x-rays are emitted from this aperture", if the radiation emitted through such aperture is x-ray radiation.

4) Each label specified in this subsection shall state, at position 2 on the required warning logotype, the maximum output of laser radiation, the pulse duration when appropriate, and the laser medium or emitted wavelengths.

5) Each non-interlocked or defeatably interlocked portion of the protective housing or enclosure that is designed to be displaced or removed during normal operation, maintenance or servicing and that would permit human access to laser radiation, shall have labels as follows:

A) For Class 3b laser radiation, the wording: "DANGER- Laser radiation when open, AVOID DIRECT EXPOSURE TO BEAM".

B) For Class 4 laser radiation, the wording: "DANGER- Laser radiation when open, AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION".

C) For protective housings or enclosures that provide a defeatable interlock, the phrase "and interlock defeated" shall be inserted after the word "open" on the labels specified in subsections (c)(5)(A) and (B) of this section.

6) The word "invisible" shall precede the word "laser" on labels and signs required by this section for wavelengths of laser radiation that are outside of the range of 400 to 710 nanometers.

7) The words "visible and invisible" shall precede the word "laser" on labels and signs required by this section for wavelengths of laser radiation that are both within and outside the range of 400 to 710 nanometers. For laser products emitting only visible wavelengths, the phrase "laser light" may be used in lieu of "laser radiation".

8) All labels placed on lasers or signs posted in laser facilities shall be positioned so as to make unnecessary, during reading, human exposure to laser radiation in excess of the MPE.

9) Labels and signs required by this section shall be clearly visible, legible and permanently attached to the laser or facility.

AGENCY NOTE:

With respect to laser systems only, labeling requirements found in 21 CFR 1040, and labels otherwise approved by the FDA, may be used in lieu of subsection (c) of this section.

Illustration A: Sample Warning Sign for Class 3b Laser Facilities

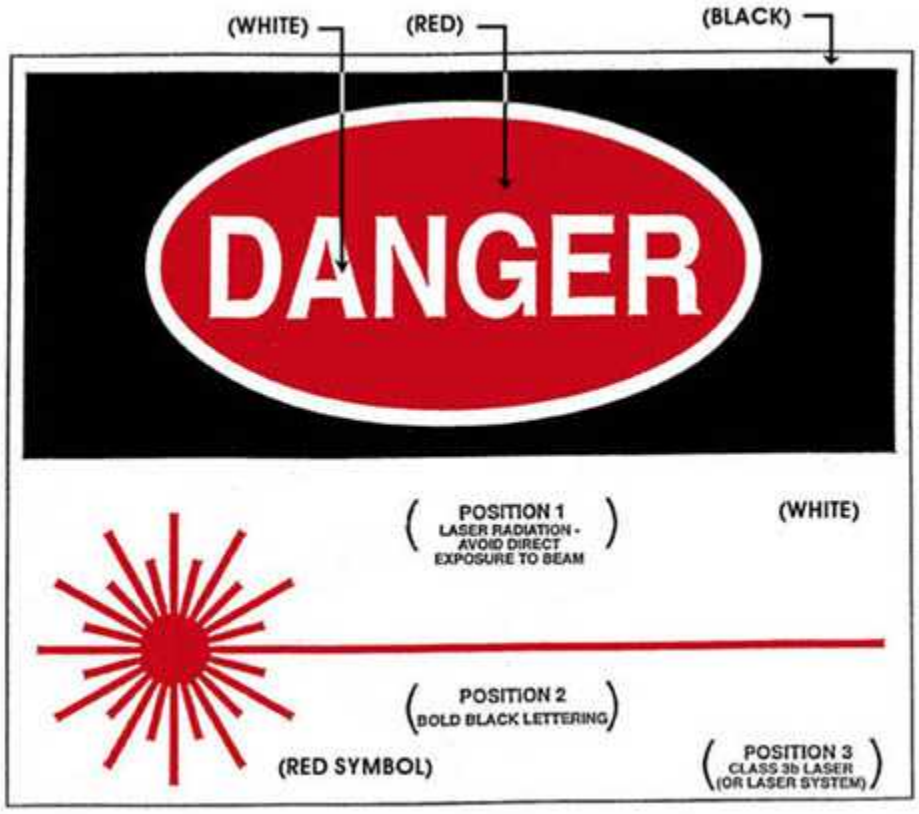
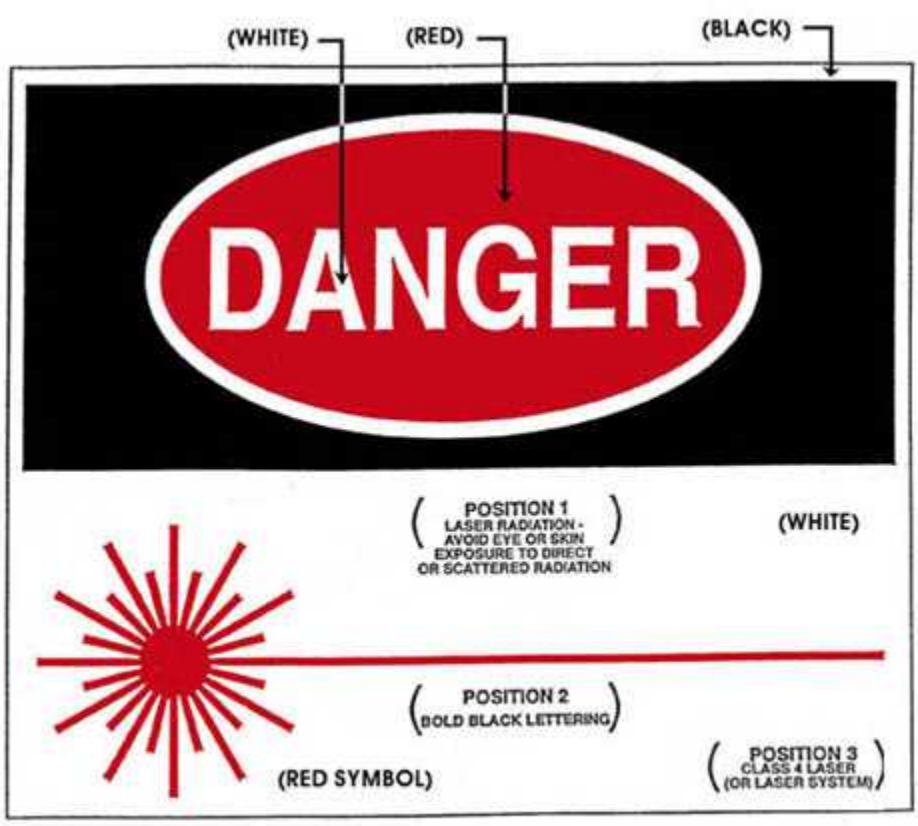


Illustration B: Sample Warning Sign for Class 4 Laser Facilities



16. Review and Approval Signatures:

Vice Chancellor for Administrative Services	10/16/07 **Date**
Director of Environmental Health & Safety	10/15/07 **Date**
Laser Safety Officer	10/17/07 **Date**