LSU School of Dentistry Laser Safety : Clinical

SAFETY PROCEDURES FOR LASER (NON-IONIZING) RADIATION

1. PURPOSE

This procedure sets forth the Louisiana State University (LSU) System non-ionizing radiation safety policy and procedural requirements of the program. The use of the term non-ionizing radiation in this document is defined as meaning non-ionizing radiation produced as a result of normal equipment use and which is at such a level that is recognized as harmful to humans. **NOTE:** This procedure does not cover non-ionizing radiation generated during welding, cutting, or burning activities.

2 .POLICY

The LSU System policy is to limit exposure to personnel from non-ionizing radiation to levels as low as reasonably achievable; however, under no circumstances is exposure to exceed appropriate Louisiana or Federal regulatory limits. To implement this policy, LSU System has set up a non-ionizing radiation safety program to ensure:

a. The use of equipment which produces non-ionizing radiation within LSU System for official business is used in a manner that will minimize risks to health and safety of the faculty, staff, students, and the general public.
b. The identification of non-ionizing radiation source hazards.
c. The prompt investigation of all reported non-ionizing radiation over-exposures and the establishment of immediate corrective action to prevent their recurrence.
d. The maintenance of an accurate inventory for accountability of the hazardous non-ionizing radiation sources within the LSU System.

3 SAFETY PROCEDURES FOR LASER RADIATION

3.1 INTRODUCTION

The term Laser is an acronym derived from "Light Amplification by Stimulated Emission of Radiation." The effects of laser radiation are essentially the same as light generated by more conventional ultraviolet, infrared, and visible light sources. The unique biological implications attributed to laser radiation are generally those resulting from the very high intensities and monochromaticity of laser light. Such sources differ from conventional light emitters primarily in their ability to attain highly coherent light (in phase). The increased directional intensity of the light generated by a laser results in concentrated light beam intensities at considerable distances.

3.2 CONTROL MEASURES

The fundamental objective of the control methods as outlined in this section is to limit the possibility of a potentially hazardous exposure, particularly to unaware transient personnel, and to provide reasonable and adequate guidance for the safe use of lasers and laser systems.

NOTE: Associated non-beam hazards such as electrical shock, chemicals, and fire are excluded from this procedure. In establishing laser control measures, the following factors determine the type and amount of control necessary:
a. Power or energy output.
b. Pulse length.
c. Pulse repetition rate.
d. Wavelength.
e. Beam path.
f. Beam shape (divergence, hot spots, atmospheric effects).
g. Number of laser systems at a particular location.
h. Laboratory layouts, position of windows, doors, etc.
i. Degree of isolation of location.
j. Type of population (informed staff in control, local knowledgeable personnel, uninformed transients).

In addition to the above factors, control measures also depend on laser classification. In general:
a. A Class 1 laser system is one that is considered to be incapable of producing damaging radiation levels during operation, and is exempt from any control measures or other forms of surveillance.
b. A Class 1M laser system is one that is considered to be incapable of producing hazardous exposure conditions during normal operation unless the beam is viewed with an optical instrument such as an eye-loupe or a telescope, and is exempt from any control measures and other forms of surveillance.
c. A Class 2 laser system is one that emits in the visible portion of the spectrum (0.4 to 0.7 μm), and eye protection is normally afforded by the aversion response.
6
d. A Class 2M laser system is one that emits in the visible portion of the spectrum (0.4 to 0.7 μm), and eye protection is normally afforded by the aversion response for unaided viewing. However, it is potentially hazardous if viewed with certain optical aids.
e. A Class 3R laser system is one that is potentially hazardous under some direct and specular reflection viewing conditions if the eye is appropriately focused and stable, but the probability of an actual injury is small. This class of laser will not pose either a fire hazard or a diffuse-reflection hazard.
f. A Class 3B laser system is one that may be hazardous under direct and specular reflection viewing conditions. This class of laser is normally not a diffuse reflection or fire hazard.
g. A Class 4 laser system is one that is a hazard to the eye or skin from the direct beam and may pose a diffuse reflection or fire hazard.
h. Use the above information and applicable sections of ANSI Z136.1-2007 as official guidelines in providing safe practices for laser operations.

Table 2. Laser classification.

Class	Dental purpose	Eye hazards	Skin hazards	LSO required
1	Caries detectors	Eye safe		No
1M				Maybe*
2	Caries detectors	Blink or aversion response		No
2M	Aiming beams	Viewing with optical aids poses potential hazards		Maybe*
3R	Low level lasers			No
3B	Low level lasers	Eye damage		Yes
4	Argon (488–514 nm)	Retinal lesions	Excessive dryness and skin burn	Yes
	Diode (810–980 nm)	Lens (cataract); retina (burn)	Excessive dryness and skin burn	Yes
	Nd:YAG (1,064 nm)	Lens (cataract); retina (burn)	Excessive dryness and skin burn	Yes
	Er:Cr:YSGG (2,780 nm) and Er:YAG (2,940 nm)	Cornea (burn); aqueous flare; lens (cataract)	Excessive dryness and skin burn	Yes
	CO_2 (10,600 nm)	Cornea (burn)	Excessive dryness and skin burn	Yes

* Application-dependent; hazard analysis is required.

3.2.1 SPECIFIC CONTROL MEASURES

To reduce the control measures required and the potential hazard from a laser source, a complete enclosure of the laser beam (an enclosed laser) shall be used when feasible. A closed installation (any location where lasers are used will be closed to transient personnel during laser operation) provides the next most desirable hazard control measure. Specific control measures to reduce the possibility of exposure of the eye and skin to hazardous laser radiation and to other hazards associated with the operation of those devices are outlined in the "American National Standard for the Safe Use of Lasers" (ANSI Z136.1-2007). Typical control measures for Class 3B and Class 4 lasers are listed below:

a. Protective housing.
b. Interlocks.
c. Service access panel.
d. Nominal hazard zone analysis.
e. Beam stop.
f. Activation warning systems.
g. Laser controlled area.
h. Equipment labels.
i. Warning signs (Fig. 3).
j. Standard operating procedures.
k. Training.
l. Authorized personnel.
m. Protective equipment (eyewear, window, barrier, curtain, etc.).

3.3 LASER PERSONNEL (Class 3B and Class 4)

Only authorized persons who have received training in the proper operation of the laser equipment shall work with such equipment.

3.4 OTHER PERSONNEL IN THE VICINITY OF LASER OPERATION (Class 3B and Class 4)

These personnel shall be duly informed concerning the potential hazards from these devices and be provided with proper personal protection equipment.

Figure 3. Sample Warning Signs for Class 3B and Class 4 Lasers

3.5 SPECTATORS (Class 3B and Class 4)

Spectators shall not be permitted into a laser controlled area, unless appropriate supervisory approval has been obtained, the degree of hazard and the avoidance procedure have been explained, and appropriate protective measures are taken.

3.6 RESPONSIBILITY OF LASER SAFETY OFFICER (Class 3B and Class 4)

The Laser Safety Officer shall have the responsibility and authority to:
a. Provide consultation services on laser hazard evaluation and control.
b. Suspend, restrict, or terminate the operation of a laser system if s(he) deems that the laser hazard control is inadequate.
c. Recommend protective equipment to control laser hazards when necessary.
d. Survey approved laser laboratories periodically.
e. Review plans for installation and/or modification of laser equipment relative to laser hazards control.
f. Investigate upon notification of a real or suspected incident resulting from laser operation and initiate corrective action.
g. Post warning signs in appropriate locations and ascertain that warning systems are functional.
h. Use the above procedures and applicable sections of ANSI Z136.1-2007 as official guidelines in providing safe practices for laser operations.

3.7 WARNING SIGNS (Class 3B and Class 4)

The laser hazard symbol shall be a sunburst pattern consisting of two sets of radial spokes of different length and one longer spoke radiating from a common center (Fig. 3). The color, dimensions, and location of the symbol within the sign shall be consistent with the specifications in ANSI Z136.1-2007.

3.8 EMPLOYEES' RESPONSIBILITY

a. An employee shall not energize or work with or near a laser unless authorized to do so by the supervisor of that laser.
b. Employees must comply with safety rules and procedures as well as applicable regulations prescribed by the laser supervisor and the Laser Safety Officer.
c. When an employee knows or suspects that an accident has occurred involving a laser, s(he) will immediately notify the supervisor and the Laser Safety Officer.
d. All employees shall wear prescribed safety equipment and observe all safety procedures at all times when working with or in the vicinity of energized lasers.

3.9 MEDICAL EXAMINATIONS (Class 3B and Class 4)

Medical surveillance of personnel working in a laser environment should be consistent with those recommended in ANSI Z136.1-2007.

3.10 STATE OR FEDERAL REGULATIONS FOR THE SAFE USE OF LASERS (Class 3B and Class 4)

At the present time no specific State of Louisiana or Federal regulations have been promulgated concerning the safe use of lasers. Until such regulations are published, LSU shall consider the ANSI Z136.1-2007 as the official guidelines to be followed regarding all aspects of laser safety.


DANGER
VISIBLE and/or INVISIBLE LASER RADIATION
AVOID EYE OR SKIN EXPOSURE
TO DIRECT OR SCATTERED
RADIATION
CLASS 4 LASER

DEFINITIONS

ANSI: American National Standards Institute; provides the American National Standard for Safe Use of Lasers (ANSI Z136.1-2007), American National Standard for Safe Use of Lasers in Health Care Facilities (Z136.3-2005) and the American National Standard for Safe Use of Lasers in Educational Institutions (Z136.5-2009).

Attenuation: The decrease in the radiation flux as it passes through an absorbing or scattering medium.

Beam: A collection of rays, which may be parallel, divergent, or convergent.

Continuous Wave: The output of a laser, which is operated in a continuous rather than a pulsed mode.

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.

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.

Electromagnetic Radiation: X-ray, ultraviolet, visible, infrared, and radio waves occupy various portions of the electromagnetic spectrum and differ only in frequency, wavelength, or photon energy.

Laser: A device which produces an intense, coherent, directional beam of light by stimulating electronic or molecular transitions to lower energy levels. An acronym for Light Amplification by Stimulated Emission of Radiation.

Laser Safety Committee (LSC): Appointed members who review, approve and enforce laser safety policies and regulations.

Laser Safety Officer (LSO): One who has authority to monitor and enforce the control of laser hazards and effect the knowledgeable evaluation and control of laser hazards.

Laser System: An assembly of electrical, mechanical, and optical components, which includes a laser.

Maintenance: Performance of those adjustments or procedures specified in user information provided by the manufacturer with the laser or laser system, which are to be performed by the user to ensure the intended performance of the product.

Maximum Permissible Exposure (MPE): The level of laser radiation to which a person may be exposed without hazardous effect or adverse biological changes in the eye or skin.

Operation: The performance of the laser or laser system over the full range of its intended functions (normal operation).

Photokeratoconjunctivitis: Photochemical injury of the corneal epithelium by ultraviolet radiation (Welder's Flash, Snowblindness).

Photoretinitis: Photochemical, "blue light" retinal injury due to a greater than ten second eye exposure to a 400-500 nm wavelength light.

Pulsed Laser: A laser, which delivers its energy in the form of a single pulse or a train of pulses, with the duration of a pulse <0.25 seconds.

Reflection: Deviation of radiation following incidence on a surface.

Retinal Photodisruption: Retinal hemorrhage including lesions, burns, bleeding, an bleaching.

Service: The performance of those procedures or adjustments described in the manufacturer's service instructions which may affect any aspect of the performance of the laser or laser system.

Scotoma: blind spot in the field of vision.

Spectator: An individual who wishes to observe or watch a laser or laser system in operation, and who may lack the appropriate laser safety training.

Specular Reflection: A mirror-like reflection.

Transmission: Passage of radiation through a medium.

Ultraviolet Radiation: Electromagnetic radiation with wavelengths smaller than those of visible radiation; 0.18 to 0.4 μm.

Visible Radiation (light): Electromagnetic radiation which can be detected by the human eye; 0.4 to 0.7μm.

Watt: The unit of power, where 1 watt = 1 joule per second.

Wavelength: The distance between two successive points on a periodic wave, which have the same phase.