Revised September 2009

SAFETY PROCEDURES FOR NON-IONIZING RADIATION

Louisiana State University

System Radiation Safety Committee

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1 GENERAL

1.1 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.

1.2 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.

2 SAFETY PROCEDURES FOR MICROWAVE AND RADIOFREQUENCY RADIATION

2.1 INTRODUCTION

Microwave energy, frequently referred to as microwave radiation, is sometimes confused with ionizing radiation. This is unfortunate since the two types of radiation have no important similarities as far as biological effects are concerned. Microwaves have some of the characteristics of infrared radiation in that they produce localized heating of the skin; however, they penetrate deeper than infrared radiation. In general, the heating produced is proportional to the field intensity of this type of radiation. Other factors influencing the effects of microwave radiation include:

a. Frequency or wavelength of the radiation from the generating equipment.

b. Period of exposure time.

c. Air currents and ambient temperatures.

d. Body weight or mass in relation to the exposed area.

e. The irradiation cycle rate, referring to the individual ON-OFF periods during a unit time interval (one minute), when total time of irradiation per minute is kept constant.

f. Orientation or position of the body or its parts.

g. Difference in sensitivity of organs and tissues.

h. Effect of reflections.

i. Blood circulation and water content.

The known biological effects of microwave radiation include:

a. Whole-body heating (such as heat overexposure).

b. Cataract formation (damage to the lens of the eye).

c. Testicular heating.

Of the three effects mentioned above, cataract formation is of the greatest concern and the lens of the eye is the critical organ.

The adverse physiological effects that result from exposures to radiofrequency radiation are due to the absorption of a sufficiently large amount of energy to produce highly localized heating in specific organs or body parts.

2.2 SAFETY PROCEDURES

The following safety procedures have been established for all LSU facilities utilizing microwave and radiofrequency sources of non-ionizing radiation **with the exception of microwave ovens intended to be used for the preparation or heating of foods**:

a. No person will be permitted to enter a radiation field where the power density exceeds those listed in Table 1 by frequency range.

b. Tests involving fields with power densities above the Table 1 values will not be conducted outside a radiofrequency anechoic chamber or equivalent type enclosure. This enclosure will be constructed so as to reduce fields below 10% of Table 1 values at all exits.

c. At least two persons shall be present when the known or suspected power density operating conditions exceed 10 times Table 1 values at any point in the field.

d. Untrained personnel will not operate equipment capable of generating fields greater than 10% of Table 1 values.

e. Warning signs (Fig. 1 and Fig. 2) shall be posted at all entrances and a flashing red warning light will be installed in areas with equipment capable of generating fields greater than Table 1 values. This warning light will be energized when the equipment is operating.

f. Interlocks that will cause power interruption when doors are opened shall be installed on all entrances to enclosures in which power densities greater than Table 1 values are generated.

g. All microwave and radiofrequency systems capable of generating fields greater than 10% of Table 1 values will be registered with the corresponding Radiation Safety Office. Registration will include the following information:

   (1) Manufacturer and model number.

   (2) Power output.

   (3) Frequency range.

   (4) Intended use.

   (5) Location.

   (6) Contact information of the principal investigator and person in charge.

h. Exposure of employees to microwave and radiofrequency radiation shall not exceed, under normal operating conditions, those levels specified in Table 1.

   (1) The above guide applies whether the radiation is continuous or intermittent, or whether whole-body or partial body irradiation is involved.

   (2) An exposure exceeding the above limitations in Table 1 shall be reported in writing to the Radiation Safety Committee.

2.3 WARNING SIGNS

The warning signs (Fig. 1 and Fig. 2) for microwave and radiofrequency radiation hazards will consist of the appropriate signal word, symbol, and pertinent sign information. The inclusion and choice of warning information or precautionary instructions is at the discretion of the user.

Table 1. Limits for Maximum Permissible Exposure (47 CFR 1.1310)

Frequency Range (MHz)	Electric Field (V/m)	Magnetic Field (A/m)	Power Density (mW/cm^2)	Averaging Time (minutes)
(A) Limits for Occupational/Controlled Exposures				
0.3-3.0	614	1.63	100	6
3.0-30	1,842/f	4.89/f	$900/f^2$	6
30-300	61.4	0.163	1.0	6
300-1,500	…..	…..	f/300	6
1,500-100,000	…..	…..	5	6
(B) Limits for General Population/Uncontrolled Exposures				
0.3-1.34	614	1.63	100	30
1.34-30	824/f	2.19/f	$180/f^2$	30
30-300	27.5	0.073	0.2	30
300-1,500	…..	…..	f/1,500	30
1,500-100,000	…..	…..	1.0	30

f = frequency in MHz

Figure 1. Typical Warning Signs for Microwave Radiation

Figure 2. Typical Warning Signs for Radiofrequency Radiation

2.4 EMPLOYEES' RESPONSIBILITY

Supervisors in charge of operating microwave and radiofrequency equipment shall have such equipment monitored periodically in areas near the power source to assure compliance with these procedures.

2.5 SAFETY DEVICES

The safety devices of microwave ovens intended to be used for the preparation or heating of foods shall not be bypassed or rendered inoperative. Such microwave ovens whose safety devices are compromised shall be taken out of service.

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.

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 summarizes the safety requirements by laser classification. The table may not be applicable for unique applications. For specialized applications refer to ANSI Z136.1-2007.

For those campuses using Class 3B or Class 4 lasers, a Laser Safety Officer shall be appointed by the Campus Radiation Safety Committee. This person shall be properly indoctrinated in laser safety and will have the vested authority to supervise the control of laser hazards.

Table 2. Control Measures by Laser Classification (ANSI Z136.1-2007)

Class	Procedural & Administrative Controls	Training	Medical Surveillance	LSO
1	Not Required	Not Required	Not Required	Not Required
1M	Required (2)	Application Dependent	Application Dependent	Application Dependent
2	Not Required (1)	Not Required (1)	Not Required	Not Required
2M	Required (2)	Application Dependent	Application Dependent	Application Dependent
3R	Not Required	Not Required (1)	Not Required (1)	Not Required (1)
3B	Required	Required	Suggested	Required
4	Required	Required	Suggested	Required

(1) Not required except for conditions of intentional intra-beam exposure applications.
(2) Control measures to prevent potentially hazardous optically aided viewing.

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.

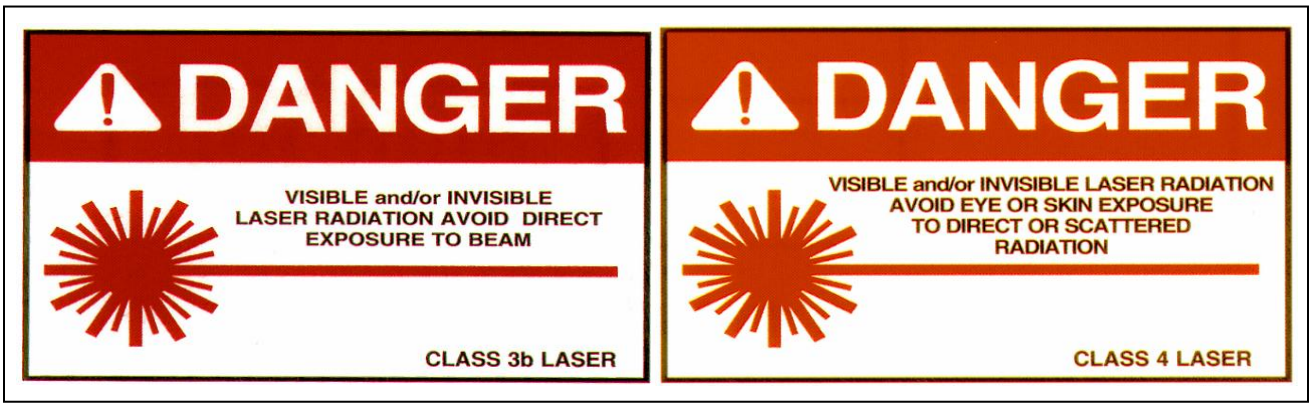

Figure 3. Sample Warning Signs for Class 3B and Class 4 Lasers

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.

4 SAFETY PROCEDURES FOR ULTRAVIOLET RADIATION

4.1 INTRODUCTION

Ultraviolet radiation is an invisible radiant energy that is produced by natural and artificial sources and accompanies much visible light.

The sun is the major natural source of ultraviolet radiation, but many artificial sources are used in industry, medicine, and research. LSU may use a variety of ultraviolet producing equipment, including germicidal lamps, chemical synthesis and analytic devices, carbon arcs, furnaces, welding and cutting torches, and photocopying machines.

Biological effects of ultraviolet radiation include damages to the eyes and skin. A typical example of the injurious effects produced by ultraviolet radiation is sunburn which is due to the naturally occurring ultraviolet rays produced by the sun. How serious the sunburn is depends on the length of the exposure and the intensity of the radiation as well as on the individual's sensitivity. Continual exposure to ultraviolet radiation speeds skin aging and may cause skin cancer.

Exposure to the eyes is particularly dangerous because the ultraviolet radiation cannot be seen, or, at first, felt. Consequently, an individual being exposed is not always aware that her/his eyes are being affected. Conjunctivitis usually occurs 4 to 8 hours after exposure. It is extremely painful and, although usually temporary, can cause permanent damage to the eyes.

4.2 PERMISSIBLE EXPOSURE LIMITS

The permissible exposure limit for ultraviolet light is somewhat complicated to determine. The limit is based on the wavelengths of the specific region of the ultraviolet spectrum to which the individual is exposed, the duration of the exposure, and the intensity of the light. The Threshold Limit Values (ACGIH TLVs and BEIs-2008) range from 3.0 mJ/cm^2 at 270 nm to 1.0×10^5 mJ/cm^2 at 400 nm.

4.3 CONTROL MEASURES

NOTE: Photocopy equipment is not covered under this policy and thus is exempt from these requirements. Ultraviolet radiation resulting from cutting, burning, or welding operations is not part of the scope of this policy and thus responsibility is deferred to individual campus or facility safety organizations.

Employees shall wear protective clothing, gloves, and face shields when operating equipment that produces ultraviolet radiation.

Enclosures or shields that are non-transparent to ultraviolet radiation can also be utilized to control exposures

Proper ventilation shall be provided to remove excessive amount of toxic gases that may be created when ultraviolet radiation reacts with air and atmospheric contamination.

Supervisors shall inform all employees that ultraviolet radiation is present in areas where such devices capable of producing ultraviolet radiation are used and shall inform those employees of the potential hazards from ultraviolet radiation.

4.4 WARNING SIGNS

Warning signs (Fig. 4) shall be placed to alert workers and the general public in areas where there are high-intensity ultraviolet light emitting sources.

Warning signs are available from commercial suppliers or may be available from the manufacturer of the ultraviolet light product.

4.5 EMPLOYEES' RESPONSIBILITY

Each employee shall:

a. Be familiar with the procedures outlined above and avoid all unnecessary exposure to ultraviolet radiation.

b. Use all required protective equipment and clothing when operating ultraviolet radiation producing equipment.

c. Check the ventilation system for adequate performance before starting work on tasks that require ventilation systems.

d. Report any ill effects on skin and eye resulting from the exposure to ultraviolet radiation due to the official business use of such ultraviolet radiation producing equipment to her/his supervisor and the Radiation Safety Office.

e. Report to her/his supervisor about any malfunctions of the ultraviolet radiation producing equipment.

Figure 4. Typical Warning Signs for Ultraviolet Radiation