Section 11
ADDITIONAL REQUIREMENTS FOR LABORATORIES USING NON-IONIZING RADIATION SOURCES

Contents

A. Scope

This Design Guide applies to all facilities, including leased properties. References are provided at the end of this chapter.

B. Non-Ionizing Radiation (NIR) Basic Safety Requirements

1. Laboratories using non-ionizing radiation sources (such as: lasers, ultraviolet lights, and large magnets) should be designed to minimize radiation exposure to personnel and the environment.

2. Laboratory designs shall utilize appropriate engineering and administrative controls to prevent radiation exposure in excess of the applicable regulations, standards, and guidelines.

3. Laboratory designs should be forwarded to the UW Radiation Safety Office (RSO) for NIR safety review and approval prior to being released for bid or beginning construction (for internal projects that are not put up for bid).

C. Controlling Access to Laser Areas

1. Doors providing access to spaces containing open-beam Class 4 lasers shall be fitted with interlocks to prevent emission from the lasers if the door is opened or to deny outside-to-inside entry during laser emission. Design of interlocks should favor the use of shutters or laser beam dumps to limit emission. Laser power supply shutoffs should not be used except where no other alternative exists. In certain situations (such as medical or surgical applications), interlocks may not be feasible or appropriate. For these applications, the EH&S RSO should be consulted regarding approval for alternatives to interlocks.

2. All doors to Class 3b and Class 4 laser areas shall have ANSI Z136.1 (2007) specification laser warning signs. Signs should be mounted so as to be visible both at the doorway and at some distance from the doorway. Signs should not be mounted above doorways. Lighted laser warning signs (or status) panels that indicate the room access status) shall be used for Class lasers and are suggested for class 3b lasers.

3. Partitions, dogleg entrances or other provisions shall be made to allow persons to don laser protective eyewear and other required PPE before entering spaces where beam hazards exist or could exist. Preferably, this provision should be made before the entry to the laboratory.

4. Appropriate barriers shall be provided to prevent Class 3b or 4 laser beams from leaving the confines of a laser laboratory through doorways, windows, etc.

D. Beam Path Management

1. Provisions shall be made to enclose Class 3b or 4 laser beams whenever possible. Class 3b or 4 laser beam paths that cross between optical tables/equipment benches or pass through barriers shall be properly enclosed and marked identifying the hazard. All enclosures shall be compatible with the laser wavelength and beam power. All laser beam paths shall be maintained at a height either above or below the eye level of standing/sitting persons who may be exposed.

2. Laser enclosures, beam stops, beam barriers and other exposed surfaces shall be diffusely reflective at the laser wavelength used. Surfaces that may create a specular reflection at the laser wavelength shall not be used.

E. Fire Safety for Lasers

1. Flammable/combustible construction materials shall be avoided in spaces housing Class 4 lasers. Materials used for beam stops or beam barriers shall not off-gas or be combustible at the beam power used. Curtains used as laser barriers shall not off-gas and shall be flame-retardant or, preferably, flameproof or laser-rated.

2. Provisions shall be made for the safe storage of laser dye solutions, solvents, and other flammable materials.

F. Electrical Safety for Lasers

1. Appropriate grounding connections shall be provided for laser power supplies and other electrical components. All optical tables shall be properly grounded. To facilitate use, all grounding connections should be properly marked.

2. Electrical systems shall be marked to show voltage, frequency, and power output. All high voltage sources shall be properly marked and secured to prevent accidental access.

G. Class 4 Laser Laboratories

1. Red mushroom-type room/area emergency shutoffs (to deactivate or reduce laser power below the Maximum Permissible Exposure, or MPE) shall be installed in a conspicuous location that is easily accessible from the laboratory entrances. The switch shall be clearly and conspicuously marked with the words “Notice – In emergency, push button to shut down laser”.

2. All laser laboratories shall be provided with easy egress. Crash-bar hardware can be used on outward-swinging doors.

H. Optical Bench Safety

Optical benches shall be secured to prevent severe movements in an earthquake. This requires anchoring a sturdy frame to the laboratory floor that surrounds and is close to (within one-half inch), but not touching, the optical bench.

I. Excimer Lasers

1. Halogen gas mixtures shall normally be stored in gas storage cabinets. All transfer lines and components in contact with halogens shall be of compatible (non-reactive) materials. Institutional toxic gas program requirements will designate the specific storage quantities allowed (depending on toxicity and other factors).

2. Conventional gas storage cabinets will effectively contain the dilute halogen and hydrogen halide in inert gas mixtures used in excimer lasers if the delivery lines are kept bone-dry. Gas storage cabinet hardware allows this to be done using bone-dry nitrogen purge gas.

3. The gas discharge from both the excimer laser and the associated halogen gas storage cabinet shall be connected to an appropriate exhaust ventilation system capable of maintaining an average face velocity of 200 fpm at the cabinet's window opening when the window is fully opened. An alarming airflow meter should be used to monitor and indicate low-flow conditions in the gas cabinet.

4. Halogen scrubber devices used on closed (non-ventilated) excimer laser systems shall meet appropriate safety standards and shall be pre-approved by the UW RSO prior to installation.

J. Laser-Generated Air Contaminants (LGAC)

Lens on laser conditions (or any place where the beam irradiance exceeds 1000 watts/cm2) should be jointly evaluated by an Industrial Hygienist and Health Physicist to identify engineering controls for laser generated air contaminants. Places where irradiances exceed 10,000 watts/cm2 shall be enclosed to the maximum extent practical and properly ventilated. Exposure to LGAC shall not be managed with the use of PPE.

K. Radio Frequency and Microwave Devices (30 kHz to 300 GHz)

1. Provisions shall be made to protect people from exposures at or above the Maximum Permissible Exposure (MPE) limits. Engineering controls shall be used in lieu of PPE or other administrative controls whenever possible. Shielding shall be designed by or be reviewed by an electronic engineer experienced in radio frequency/microwave design.

2. Provisions shall be made to restrict access and post appropriate warnings for locations where field strengths could exceed the MPE. Appropriate ANSI specification warning signs shall be provided to identify such areas. Signs should be mounted so as to be visible both at the doorway and at some distance from the doorway. Signs should not be mounted above doorways.

3. To prevent exposures exceeding the MPE for radio frequency electrical currents, barriers and/or cages shall be provided to protect persons from contact with or close proximity to such currents. These provisions shall be designed or reviewed by an Electronic Engineer experienced in radio frequency/microwave design.

L. Sub-radio Frequency Fields (<30 kHz)

1. Magnetic Fields: Overexposures at these frequencies are very unlikely. The most likely situation will entail a frequency of 60Hz. The exposure limit for 60 Hz is 0.2 mT (2 G or 160 A/m). This is a partial and whole body ceiling limit, although limbs can receive 5 times this amount, and hands and feet 10 times.

2. Electric Fields: Overexposures are unlikely if electric sources are insulated and grounded. The exposure limits vary according to the frequency range. For a 60 Hz filed, the limit is 25 kV/m. However, the worst-case situation would be at 30 kHz, where the limit is 625 V/m.

3. There are a few types of cardiac pacemaker that are very sensitive. Some models are susceptible to interference by a power-frequency (50/60 Hz) as low as 2 kV/m. It is recommended, therefore, lacking specific information that exposure to pacemaker wearers be maintained at or below 1 kV/m.

M.Static (Zero Hz) Magnetic Fields

1. As part of the design process, the magnetic field in the facility shall be mathematically modeled to identify where pacemaker hazards (>5 G) and kinetic energy hazards (>30 G) exist. Places where excessive whole-body exposures (>600 G) could occur shall also be identified. If it is determined that shielding is required, an experienced consulting firm should be hired to design all electric or magnetic field shielding.

2. Provisions shall be made to prevent access to places where whole-body magnetic fields exceed 600 G. Areas such as hallways, stairways, and offices shall be located where fields are <5 G to allow completely unrestricted access.

3. The University of Washington enforces ACGIH TLV guidelines for static magnetic fields, which is somewhat more restrictive than ICNIRP.

4. Provisions shall be made to secure and restrict access to places where whole-body fields exceed 5 G. This is based solely on the possible effect that 5 gauss fields can have on some pacemakers.

5. A variety of prosthetic devices, medical equipment, makeup, and personal articles can also behave in a hazardous manner in stronger fields.

6. Appropriate ANSI Z535 specification warning signs shall be provided to identify such areas. Signs should be mounted so as to be visible both at the doorway and at some distance from the doorway. Signs should not be mounted above doorways.

7. Provisions should be made for persons to securely store their wallets, magnetic media, keys, and other ferrous-alloy tools and articles for safekeeping before entering places where fields exceed 5 G.

8. Appropriate discharge shall be made to direct cryogenic gases from a quenched superconducting magnet to a safe, unoccupied location to avoid exposing persons to an oxygen-deficient atmosphere. The issue of preventing oxygen deficiency during a quench condition shall be addressed in the design of locations for superconducting magnets. Doors to locations that may be subjected to gases during a quench shall open outwards to assure they can be opened should the laboratory become pressurized.

9. It is estimated that eighty liters of liquid helium (56,000 liters of gas at the 1:700 expansion ratio) can be ejected from the magnet dewar in fifteen to thirty seconds.

N. Ultraviolet Radiation

1. Provisions shall be made to protect people from exposures at or above the Maximum Permissible Exposure Levels (MPE) defined for Actinic UV Radiation Effective Irradiances. Engineering controls may be used in place of PPE or other administrative controls but are not required. Proper UW rated plastics, glass and/or shielding design should be evaluated by the Radiation Safety Office.

2. Engineering controls such as automatic shut off switches and locked doors provide superior protection over measures such as signage. Time limits for exposure are based on a person not using proper PPE.

3. Provision should be made to restrict access and post appropriate warnings for location where irradiance could exceed the MPE. Appropriate warning or caution signs shall be provided to identify such areas. Signs should be mounted so as to be visible both at the doorway and at some distance from the doorway. Signs shall be placed on the UV source if the source is portable or moveable. Signs should not be mounted above the doorway.

4. To prevent exposures exceeding the MPE for Ultraviolet Radiation, care should be taken to ensure that all glass, windows, or visible access to the area is covered

with UV rated material for the wavelength of the UV source. These materials should be reviewed by the RSO prior to installation.

5. All overhead UV uses for germicidal purposes should be reviewed by the RSO prior to construction. Many portable and pre-constructed devices exist that would meet or exceed most requirements for overhead UV.

6. UV used for sterilization of water or other materials or solutions should be properly shielded. Devices of this type can put out significant amounts of UV above the MPEs and should be reviewed by the RSO prior to permanent installation.

O. References

1. ACGIH – TLV/BEI 2013

2. ANSI C95.1-1999

3. ANSI C95.1-2005

4. ANSI Z136.1-2007

5. NFPA 115

6. ICNIRP "Guidelines on Limits of Exposure to Static Magnetic Fields" 2009