

Section

5

Radiation Hazards - Recognition, Evaluation, and Control

I. IONIZING RADIATION

A. **Recognition of Ionizing Radiation Hazards**

Ionizing radiation is radiation that interacts with matter to form ions; high-energy electromagnetic radiation and particle radiation are capable of producing ions in their passage through matter. Types of ionizing radiation include alpha particles, beta particles, x-rays, and gamma rays. Commonly used radioisotopes on campus include P-32, S-35, C-14, H-3, and I-125.

B. **Evaluation of Ionizing Radiation Hazards**

1. Sources of Ionizing Radiation

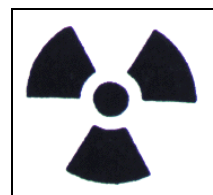
- a. *Radioisotopes* - These are most often used for tracing biological processes.
- b. *X-ray machines* - These are used for geological, metallurgical, and material science analyses including x-ray crystallography, and for irradiation of biological samples.

B. **Control Methods for Ionizing Radiation Hazards**

In order to keep exposures to ionizing radiation as low as possible, there is a system at UCI to safely use radioisotopes and radiation-producing machines. Radiation users should refer to the UCI Radiation Safety Manual, the UCI Radiation Safety Syllabus, or the UCI Radiation Safety Factsheet for more information.

1. Work/Storage Area Identification

Each entrance to an area where an ionizing radiation source is being used or stored must be posted with an appropriate warning sign that includes the radioactive material/radiation trefoil symbol.



2. Working with Ionizing Radiation Sources

It is important to understand the type (i.e., gamma, beta, alpha, x-ray) and energy of the radiation emitted by the source you are working with; this determines the handling procedures, shielding, and monitoring equipment to be used.

- a. Those working with ionizing radiation must be trained in radiation safety. Radiation Safety Part I is an online course and is required **prior** to beginning work with radioactive materials. Radiation Safety Part II is a classroom session required within 6 months of taking Part I. Radiation-Producing Machine Safety Orientation is required **prior** to beginning work with radiation-producing machines or accelerators.
- b. Responsible PIs using radioactive materials must be issued Radiation Use Authorizations (RUAs). All users must be listed on the RUA. The RUA indicates the amounts and types of radioactive materials and/or radiation-producing machines being used, by whom, where, how, and with what safety precautions.
- c. More hazardous or delicate procedures should be handled by more experienced personnel (i.e., pipetting stock solutions or aligning x-ray machines).
- d. Regular testing for radioactive contamination must be conducted.
- e. Users may receive a whole body dosimetry badge or finger ring to monitor radiation dose, if deemed necessary by EH&S.
- f. All appropriate lab personnel must be informed of the potential hazards and safety procedures involved in the use of radiation sources, including:
 - The nature of the radiation hazard and the properties of other materials being used which could affect exposure.
 - Radiation detection instrumentation and how to use it.
 - Minimizing exposure (shielding, remote handling tools, dry runs, contamination control, protective clothing).
 - Appropriate waste disposal practices.
 - General lab safety; housekeeping.
 - Emergency guidelines.
- g. If unsure of any of the above, refer to the UCI Radiation Safety Manual, your course protocol, your supervising professor, or EH&S.

II. NON-IONIZING RADIATION

A. **Recognition of Non-Ionizing Radiation Hazards**

Non-ionizing radiation is electromagnetic radiation that is not of sufficient energy to ionize matter, though it is capable of causing injuries. Non-ionizing radiation can cause photochemical and thermal effects by exciting electrons in atoms to higher energy levels and by producing molecular excitation. Laser radiation, radio-frequency and microwave radiation, infrared (IR) radiation, and ultraviolet (UV) radiation are all examples of non-ionizing radiation.

B. Evaluation of Non-Ionizing Radiation Hazards

1. Sources of Non-Ionizing Radiation

a. *UV Radiation*

Chronic exposure to UV radiation may cause premature skin aging, excessive wrinkling of the skin, skin cancer, and cataracts (clouding in the lens of the eye).

- i. UV-A (315 - 400 nm) - "Black Light". Effects include tanning (and some burning) of the skin, and fluorescing of ocular media (corneal and lens effects).
- ii. UV-B (280 - 315 nm) - "Erythematous UV". Effects include "sunburn" of the skin, inflammation of the cornea of eye, and cataracts.
- iii. UV-C (100 - 280 nm) - "Germicidal UV". Principal effect is inflammation of the cornea of the eye.

b. *Infrared (IR) Radiation*

- i. IR-A (700 nm - 1.4 μm) - "Near IR". High intensity may cause skin burns and retinal thermal injury.
- ii. IR-B (1.4 - 3.0 μm) and IR-C (3.0 μm - 1 mm) - "Far IR". High intensity may cause skin burns and corneal inflammation.

c. *Radio-frequency (RF) and Microwave (MW) Radiation*

- i. RF (0.3 - 30 MHz) and MW (30 MHz - 300 GHz) - Effects may include formation of cataracts, neurological effects, male sterility and possibly cancer.

d. *Laser Radiation*

("Light Amplification by Stimulated Emission of Radiation")

- i. Lasers may emit UV, visible, or IR radiation.
- ii. Laser radiation has unique properties: monochromatic (one wavelength emitted), coherent (all waves in phase), highly directional (low beam spreading), high energy density.
- iii. Additional laser hazards

- Electrical - most lethal hazard! Only qualified individuals may perform laser power supply service or maintenance.
- Chemical - dyes in liquid laser media, toxic gases.
- X-radiation - from high voltage vacuum tubes.
- Fire - Class 4 laser beam (generally IR laser).
- Mechanical - ergonomic injuries.

C. Control Methods for Non-Ionizing Radiation

1. UV Radiation

Eye protection (goggles, safety glasses, face shields) and protective clothing should be worn when working with high-level UV sources, which should ideally be enclosed or shielded to prevent exposures. When fully enclosed and interlocked UV sources are used, protective eyewear and clothing are not needed.

2. IR Radiation

Same as UV (eye and skin protection). Measures to avoid hyperthermia (over-heating of the body) may be needed.

3. Radiofrequency (RF) and Microwave (MW) Radiation

Sources must be properly isolated and shielded.

4. Laser Radiation

Lasers are classified Class 1-4, depending upon their capacity to produce injury. Each class is governed by specific guidelines regarding engineering, administrative and personal protection control measures:

a. *Class 1 (exempt laser) - i.e., laser in CD player*

- Laser should be labeled.
- Laser must be enclosed and interlocked (for fully-enclosed Class 3b or 4 laser).

b. *Class 2 (low power laser) - i.e., supermarket bar code scanner*

- Laser must be properly labeled.
- Do not stare into the beam!

c. *Class 3a (medium power laser) - i.e., laser pointer*

- Laser must be properly labeled and an area sign ("Caution") should be posted in some cases (for research lasers only).

- Do not stare into beam or view directly with optical instruments!
- Eye protection may be needed in rare circumstances.

d. *Class 3b (medium power laser) - i.e., some research lasers*

- Laser must be properly labeled and an area sign ("Danger") must be posted.
- Laser operators must be adequately trained (including laser safety).
- Written operational safety procedure is highly recommended.
- Many engineering controls are required (keyed master switch, beam stops, laser interlocks, beam tubes, etc.).
- Laser controlled area must be established.
- Avoid exposure to direct and specularly scattered beam (scatter from mirror-like surfaces)!
- Eye protection is required.

e. *Class 4 (high power laser) - i.e., most medical & research lasers*

- All measures listed above for Class 3b lasers.
- Avoid eye or skin exposure to direct or scattered (specular and diffuse) radiation!
- Eye protection (and occasionally skin protection) is essential.
- Activation warning systems (alarms, lights) must be installed in most cases.

Ten Most Common Causes of Laser-Produced Eye Injuries

- 1. Unanticipated eye exposure during alignment.**
- 2. Fatigue, leading to carelessness or inappropriate shortcuts; horseplay.**
- 3. Misaligned optics, upwardly- directed beams, or beams at eye-level.**
- 4. Available eye protection not worn, or the wrong eyewear worn.**
- 5. Overconfidence; feeling of complacency or invincibility.**
- 6. Inadequate beam containment or isolation; beam directed off of the plane of the optical table**
- 7. Operator unfamiliar with laser equipment (not sufficiently trained).**
- 8. Unneeded reflective items on optical table causing stray radiation.**
- 9. Failure to follow standard operating procedures due to hurrying, etc.**
- 10. Manufacturer-installed safety features bypassed.**