

Radiation Hazards - Recognition, Evaluation & Control

1. IONIZING RADIATION

A. RECOGNITION OF IONIZING RADIATION HAZARDS

Ionizing radiation is radiation, which 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 and beta particles, x-rays, gamma rays, etc.

B. EVALUATION OF IONIZING RADIATION HAZARDS

1. Sources of Ionizing Radiation: Radioisotopes
2. Commonly used radioisotopes on campus include P-32, S-35, C-14, H-3 & I-125. They are most often used for tracing biological processes.
3. X-ray machines: These are used for geological, metallurgical and material science analyses, and occasionally for irradiation of biological samples and x-ray crystallography.

C. CONTROL METHODS FOR IONIZING RADIATION

In order to keep exposures to ionizing radiation as low as possible, there is a system at UC Davis to safely use radioisotopes and radiation-producing machines. Radiation users should refer to the UC Davis Radiation Safety Manual.

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 which includes the radioactive material/radiation trifoil 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.
 - Those working with ionizing radiation must be trained in radiation safety; initial training sessions, are given monthly at EH&S. Protection Section of EH&S.
 - PI's 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 precautions.
 - More hazardous or delicate procedures should be handled by more experienced personnel (i.e., pipetting stock solutions or aligning x-ray machines).
 - Regular testing for radioactive contamination must be conducted.
 - Users may receive a dosimeter badge or ring to monitor radiation exposure, if deemed necessary by EH&S.
 - 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.
- ✓ preventing exposure (shielding, remote handling tools, dry runs, contamination control, protective clothing).
- ✓ appropriate waste disposal practices.
- ✓ general lab safety; housekeeping.
- ✓ emergency guidelines.
- Refer to the UC Davis Radiation Safety Manual, laboratory protocol, supervising professor or EH&S, if unsure of any of the above.

2. 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 damaging the human body. Non-ionizing radiation can cause photochemical and thermal effects by exciting electrons in atoms to higher energy levels, and by producing molecular excitation. Lasers, radio-frequency and microwave radiation, IR radiation, and UV radiation are all examples of non-ionizing radiation.

B. EVALUATION OF NON-IONIZING RADIATION HAZARDS

1. Sources of Non-Ionizing Radiation

- UV Radiation

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

- 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.

- IR Radiation

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

- 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

- 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 be enclosed or shielded to prevent exposures. When fully enclosed and interlocked UV sources are used, protective eye-wear and clothing are not needed.

2. IR Radiation

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

3. Radio-frequency (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 regulations regarding engineering, administrative and personal protection control measures:

- 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).
- Class 2 (low power laser) - i.e., bar code scanner
 - ✓ laser must be properly labeled.
 - ✓ do not stare into the beam!
- Class 3a (medium power laser) - i.e., laser pointer
 - ✓ laser must be properly labeled and area sign ("Caution") should be posted in some cases.
 - ✓ do not stare into beam or view directly with optical instruments.
 - ✓ eye protection may be needed in rare circumstances.
- Class 3b (medium power laser) - i.e., some research lasers
 - ✓ laser must be properly labeled and 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, etc.).
 - ✓ laser controlled area must be established.
- 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.
5. Ten Most Common Causes of Laser-Produced Eye Injuries
- Unanticipated eye exposure during alignment.
 - Fatigue, leading to carelessness or inappropriate shortcuts; horseplay.
 - Misaligned optics, upward directed beams, or beams at eye-level.
 - Available eye protection not worn, or the wrong eyewear worn.
 - Overconfidence; feeling of complacency or invincibility.
 - Equipment malfunction.
 - Operator unfamiliar with laser equipment (not sufficiently trained).
 - Improper restoration of equipment following service.
 - Failure to follow standard operating procedures due to rushing, etc.
 - Manufacturer-installed safety features by-passed.

Please review the UCD Radiological Safety website for further information:

<https://safetyservices.ucdavis.edu/units/ehs/research/radiological>