Laboratory Safety Bulletin

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Location: Essex Hall / B-37 • Hours: 8:30 am to 4:30 pm (M-F)

Radiation Safety – General Laboratory Awareness

Overview:

The University of Windsor is required to provide general radioisotope awareness training to individuals who may come into contact with a radioisotope source during their employment, while studying, or when visiting a laboratory which has been issued an internal radioisotope permit. This document is intended to help Permit Holders provide general information on radioisotopes, their utilization with a specific lab, identification of designated working areas, and emergency contact information.

Disclaimer:

General Laboratory Awareness on Radioisotopes is not a substitute for laboratory specific training and/or completion of the University of Windsor's Radiation Safety Training for End-Users.

Background:

Radiation, or more specifically, ionizing radiation is found everywhere in our environment. From cosmic radiation to radon from the earth seeping into your basement to the dentist's Xray machine, it's everywhere. And, just like chemical toxicity, it's ''the dose that makes the poison.'' But unlike many chemicals, radiation cannot be seen or sensed, and it is also difficult to detect without specialized equipment. Therein lays the biggest fear – fear of exposure to something unseen and undetectable.

While fear of radioactive sources, especially those found a laboratory setting, is normally unwarranted, respect is certainly in order. The University of Windsor has developed a Radiation Safety Program which includes administrative, laboratory, and personnel management practices to reduce or elimination of unnecessary exposure to radiation.

Types of Radiation:

Alpha particles are 4-He nuclei that are produced primarily from the radioactive decay heavier elements such as radium, thorium, uranium and polonium and americium.

Beta particles are, in essence, electrons whose origin was from the nucleus (i.e. nuclear decay) of an atom and whose charge may be positive (''positron'' or b+ decay) or negative (b- decay, more common).

Neutrons as ionizing radiation are the result of nuclear decay, fission or from neutron-producing mixtures such as an 241Am–9Be mixture. Devices called ''neutron howitzers'' (which contain Am–Be or Pu– Be sources) can be found in physics departments for instructive purposes (in half-life experiments) or in engineering departments and organizations for non-destructive testing.

Both gamma rays and X-rays are electromagnetic in nature, differing only in the production. Gamma rays are the product of nuclear decay, while X-rays are produced by inner orbital electron transitions as the result of electron bombardment of a target.

Types of Radiation:

Injury to living cells by ionizing radiation is the result energy transfer to the individual molecules though which the radiation passes. Particles interact with target molecules and atoms either by direct collision alone as in the case of neutrons, or though both collisions and electromagnetic interactions with the atoms and molecules of the target.

Non-particulate radiation (gamma and X-rays) interact with target molecules solely though electromagnetic interactions.

Charged particles interact with matter primarily through electromagnetic field interaction between the particle and the material (a ‘‘collision,’’ of sorts). How far a charged particle travels in the material will depend on the initial kinetic energy of the charged particle, the charge value of the particle and the density of the target material. With each interaction, the particle will slow down until it is stopped.

Uncharged particles (neutrons) interact solely by collision with target atoms. Basic physics again tells us that during a collision, the maximum energy is transferred when the two colliding objects have the same (or approximately the same) mass. Therefore, in order to slow down neutrons, one would want a material that has a lot of hydrogen in it

Non-particulate radiation (gamma, X-ray) interacts with matter solely though electromagnetic interactions. Basic college physics tells us that there are three types of non-particulate, electromagnetic interactions:

> Photoelectric effect: The target material absorbs the gamma or X-ray, ejecting an electron. The incident gamma or X-ray’s energy is completely transferred to the electron, less the binding energy of the electron.
>
> Compton scattering: The incident gamma or X-ray looses some of its energy to cause the ejection of an electron. The result is an electron and a lower energy gamma or X-ray.
>
> Pair production: Incident gamma or X-rays in close proximity to an atomic nucleus may electromagnetically interact with that nucleus, causing the production of an electron and a positron. The positron will shortly undergo pair annihilation with an electron to produce two gamma rays. Pair production is important only when working with high-energy gamma and X-rays impacting high atomic number materials.

Radiation Detection:

Detection and measurement of ionizing radiation can be achieved by a number of different methods; however all depend on the energetic interaction of radiation with matter. Two premier methods are:

- Ionization within gas filled chambers, and;
- Scintillation methods.

Gas-filled detectors are available in a variety of shapes, sizes and configurations. In many configurations, a chamber (be it a flat, ‘‘pancake’’ type chamber or a tube) is filled with a gas such as nitrogen or a nitrogen–methane mixture. Many have a thin, Mylar window which will allow some types of particulate radiation to enter, provided it has enough energy to penetrate the Mylar film.

Geiger counters (or Geiger-Mueller detectors) are very sensitive radiation detectors and are designed as counting or count-rate instruments. Their sensitivity allows the instrument to detect ionizing events regardless of the type of (alpha, beta or gamma). However, this sensitivity is also a big disadvantage as a Geiger-Mueller instrument cannot discriminate between alpha, beta and gamma radiation, and it should be noted that even with a Mylar window, Geiger-Mueller detectors are very inefficient for alpha and low-energy beta particles. A typical field instrument that uses the Geiger- Mueller principles is shown in Figure 1.

Scintillation instruments use light produced by the interaction of radiation with a light-producing material (liquid or solid) to detect radiation. The amount of light during an interaction is proportional to the energy of radiation. Photomultiplier tubes and multichannel analyzers are often employed with scintillation instruments in order energy-discriminate and produce qualitative and quantitative spectra.

Radiation Protection:

In concept, radiation protection is a relatively easy task to accomplish: One needs to only control the overall exposure to radioactive sources or material. This is accomplished by a three-pronged approach to exposure control – time, distance, and shielding.

Time: Since we’re concerned with the overall dose (sievert), limiting the time one is exposed to a radiation source naturally limits the dose.

Distance: Small sources of radiation (a ‘‘point source’’) obey the inverse square law of electrodynamics for intensity. That is, if we can double the distance we work from a source; we reduce the exposure rate (intensity) by a factor of four. Increasing the distance to a small source can be accomplished though the use of tools or though engineering systems (robotics) for very intense sources.

Shielding: Using a radiation absorbing material between the worker and the radiation source is an excellent method for reducing the exposure rate to the worker. However, the shielding material must be appropriate for the radiation type.

Radiation Safety Program:

The University of Windsor has developed a radiation safety program which includes the following:

- Designation of responsible individuals such as the Radiation Safety Officer (RSO) and the Radiation Safety Committee ;
- Exposure limits and exposure control methods;
- ALARA program;
- Monitoring requirements;
- Source security and inventory;
- Requirements for using radioactive material such as designated locations, personal protective equipment, hygiene, and waste management;
- Sign requirements;
- Information and training requirements;
- Emergency actions and emergency contact information
- Recordkeeping requirements

For more information, please visit the University of Windsor Radiation Safety Program website at www.uwindsor.ca/radiation.

Radiation Safety Resources:

University of Windsor's Radiation Safety Manual (2007) (available online – www.uwindsor.ca/radiation or by email ccc@uwindsor.ca)

Radionucleotide Hazards, Howard Hughes Medical Institute (Video) http://www.uwindsor.ca/radiation - select "Training Videos" from the left hand menu.

References:

Elston, Harry J. The Chemical Hygiene Officer's radiation protection primer. Journal of Chemical Health and Safety, **2007**, 10 (1).

Radiation Safety Officers Handbook, Part A. Advisory Committee on Radiological Protection, Canadian Nuclear Safety Commission (INFO-0718), 2000.

Your Role:

Only individuals who have completed the University of Windsor's Radiation Safety Training for End-Users may manipulate radioactive materials. You are expected to follow the direction provided by your supervisor, his/her delegate, or a member of the institutions safety department as it relates to laboratory safety.

Please ensure that you complete and submit the attached declaration.

Site Specific Information:

Tour laboratory and identify the location of all sources of radioactivity
(i.e. benches, fridges, freezers, fume hoods, etc.)

Identify methodology for determining if an item or area is radioactive
For example, warning signs/labels, monitoring devices, etc.

Identify location of Spill Control and Laboratory Classification Posters
(Please highlight emergency contact names and numbers)

Outline the expectations that individuals who have not successfully completed Radiation Safety Training for End-Users must not handle radioisotopes.

Review steps taken within your laboratory to reduce exposure to radioisotopes.
For example, shielding, contamination monitoring, etc.

General Laboratory Awareness – Radioisotopes

Training Declaration

University of Windsor
thinking forward

Name	
Department	
Supervisor	
UWin ID	

"I declare that I have reviewed the materials presented within this document and have review the utilization, and storage of radioisotopes within the laboratories under the control of my supervisor. Furthermore, my supervisor has provided me with a tour of his/her lab, identified controlled areas, and provided me with adequate information to pertaining to radioisotope utilization."

Trainee's Signature	Supervisor's Signature
Date	Date

Permit Holder: Please keep a copy of this training record within your files for audit purposes.