Dosimeters may be used to monitor personnel and areas where radiation sources are used. The Ohio Department of Health (ODH) regulations require that personnel monitoring be performed if a worker is "likely to receive" a dose in excess of ten percent of the regulatory limits. The University of Cincinnati (UC) radioactive material (RAM) license and the Radiation Control and Safety Program (RCSP) requires personnel to wear dosimeters when using RAM which emit betas with maximum energies greater than 250 keV, or gamma or x-rays of any energy. Exemptions from the license and RCSP requirements may be approved by the Radiation Safety Committee (RSC) on a case-by-case basis.

Two types of external personnel dosimeters are used at UC: (1) Optically Stimulated Luminescence (OSL) and (2) Thermoluminescent Dosimeter (TLD). OSL dosimeters are used for monitoring radiation exposure to the whole body. TLD rings are used to monitor radiation exposure to the hand. Both types of dosimeters are able to measure radiation exposure from x-ray, beta, or gamma radiation.

The OSL measures the radiation exposure using a thin layer of aluminum oxide. After use of the dosimeter, the aluminum oxide is stimulated with a laser light. The laser light causes the aluminum oxide to luminesce. The luminescence is proportional to the amount of radiation exposure. Inside the whole body dosimeter is the OSL detector and a multi-element filter packet. The different filters are used to determine the quality (type and energy) of radiation that caused the exposure received by the dosimeter and calculate the effective radiation dose equivalent (in mrem) at specific depths in tissue. The dosimeter is enclosed in a light-tight water-resistant blister pack, independent of the holder. The dosimeter needs to be snapped out of its holder prior to returning for processing.

A TLD measures ionizing radiation exposure by measuring the amount of visible light emitted from a crystal in the detector when the crystal is heated. The amount of light emitted is dependent upon the radiation exposure. A TLD is a phosphor, such as lithium fluoride (LiF) in a solid crystal structure. When a TLD is exposed to ionizing radiation at ambient temperatures, the radiation interacts with the phosphor crystal and deposits all or part of the incident energy in that material. Heating the crystal causes the crystal to vibrate, releasing trapped electrons in the process. The released electrons return to the original ground state, releasing the captured energy from ionization as light, hence the name thermoluminescent. The released light is counted using photomultiplier tubes and the number of photons counted is proportional to the quantity of radiation striking the phosphor. The TLD is encapsulated inside the identification cover on the ring. No separation of the TLD from the cover is possible, so the identity of the chip and the wearer is always maintained.

Dosimeters should be stored and handled with care and to prevent damage. Do not subject to excessive heat, humidity, or mechanical pressure. Minimize exposure to
laboratory chemicals. Dosimeters should be stored in a cool, dry area away from all sources of radiation and chemically active gases or vapors.

If you have been issued a dosimeter to monitor your radiation exposure, follow a few simple rules to ensure the dosimeter accurately records your radiation exposure.

- Wear only your assigned dosimeter; never wear another worker’s dosimeter.
- Dosimeters should be worn at a position appropriate for the work being performed (i.e., at the level where the highest exposure would be expected, for example, at waist-level if standing in front of the RAM-use bench or on the collar if the head and upper body are receiving the highest exposure.) Persons who wear lead aprons to reduce radiation exposure to the trunk of the body may be required to wear two dosimeters, one outside the lead apron at the collar and a second dosimeter under the lead apron at approximately waist level.
- Do not store your dosimeter near radiation sources or heat sources.
- If you suspect radiation contamination on your dosimeter, immediately decontaminate and promptly report the contamination to the RSOf. A contaminated dosimeter should be gently washed with soap and water and remonitored to ensure it is free of contamination. It should then be wrapped (e.g., placed in an envelope) before being brought to the RSOf. The RSOf will provide instruction for return of the dosimeter. A replacement dosimeter will be provided. Information regarding the contamination needs to be provided to the RSOf with the dosimeter.
- Never intentionally expose your dosimeter to any radiation.
- Do not wear your dosimeter during personal medical or dental procedures (e.g., x-rays, tests, nuclear medicine, etc.). UC-issued dosimeters are strictly for occupational use.
- Return your dosimeter to the RSOf promptly at the end of the monitoring period.

Dosimeter reports are received at the RSOf monthly. The reports are reviewed by the Radiation Safety Officer. You will be notified immediately if your dosimeter indicates an overexposure. You will also be notified if your dosimeter indicates a dose above an “ALARA investigational level.” Permanent records of recorded doses are maintained by the RSOf. Annually (usually in April or May) individuals are provided a report that covers their radiation dose from the prior year. You may request your exposure history at any time by contacting the RSOf.

**Audit Questions and Answers**

A list of general knowledge questions is included with each audit. The purpose of the questions is two-fold. One is to prepare individuals for an Ohio Department of Health (ODH) inspection. The other is to assure individuals have the knowledge to work safely and compliantly with radioactivity.

**Question:** When performing experiments using unsealed RAM, why is it important to perform a survey (meter and/or wipe test) prior to using RAM, throughout the RAM procedure, and post-use?

**Answer:** A pre-use survey is a good radiation safety practice since it determines if a prior user may not have performed a good survey and/or necessary decontamination. When performing experiments using unsealed RAM, a calibrated survey meter should be available periodically surveying to prevent the spread of contamination. Good radiation safety practices include a post-use survey to ensure contamination detection and control. Areas checked should include: hands, shoes (top and bottom), other areas of the body, all RAM work areas, floor spaces immediately adjacent to RAM work/storage areas, and floor spaces between RAM work/storage areas (where RAM was transported).

**Question:** What scale on a survey meter is used when initially performing a survey? Why?

**Answer:** The lowest scale should be used when initially performing a survey. Why?

**Answer:** The lowest scale should be used when initially performing a survey. Starting with the lowest scale assures the most sensitive survey. If scale exceeded, move to next scale. A survey meter can’t detect H-3 due to very low energy of beta. Prior to using a survey meter, always perform preoperational checks which include a physical check to ensure no damage, a battery check, and verification calibration has not expired. It is also good practice to check against a known radiation source to ensure meter responds.
When surveying, the probe should be held approximately 1 cm from the surface and moved laterally at a rate of 2-5 cm per second.  

**Question:** When, where, and how is an extremity dosimeter expected to be worn?  
**Answer:** Any time you are working with RAM requiring dosimetry (radionuclides emitting only alpha or beta particles with maximum energies < 250 keV are exempt from this requirement) an extremity dosimeter must be worn. The extremity dosimeter is worn underneath gloves on the hand likely to receive the highest exposure with the detector facing the palm.  

**Question:** What activity of RAM requires a documented survey more frequent than monthly?  
**Answer:** RAM quantities greater than 200uCi used in one procedure require a documented survey within one week. RAM quantities < 200uCi used in one procedure require at least monthly documented surveys. An undocumented survey is required to be performed as soon as practical after a RAM procedure is completed.  

**Question:** What is the trigger level for analyzing a wipe test sample?  
**Answer:** Any wipe test sample >100 cpm above background may indicate removable contamination that needs to be handled. If unexpected, recount the wipe test sample in question due to the possibility of a false positive (LSC only). If a recount still indicates > 100 cpm above background, the wipe test sample should be considered contaminated.  

**Question:** What action(s) is required for a wipe test sample > 100 cpm above background?  
**Answer:** When a contaminated wipe is verified, the appropriate action(s) is to decontaminate the area in question, resurvey the area, and contact the Radiation Safety Office for assistance, if necessary. Calls to the RSO of should be made immediately if actively working with > 100 uCi, if working with ≤ 100 uCi and contamination found outside the marked RAM work area, or anytime contamination is detected on the floor.  

**Question:** Where can information are found for radiation workers about the risks associated with exposure during pregnancy?  
**Answer:** The Radiation Worker manual provides information about the biological effects associated with radiation exposure. Information about the risks associated with exposure during pregnancy can be found in NRC Regulatory Guide 8.13. The Reg. guide is located on the NRC website (www.nrc.gov) or a copy can be obtained from the Radiation Safety Office. Pregnant workers or individuals who are considering becoming pregnant should review Reg. guide 8.13.
Authorized Users (AU) and/or their staff are encouraged to call the Radiation Safety Office (RSOF) for assistance with any radiation safety concerns. The RSOF will provide advice and/or assistance to AUs or their staff on solutions to problems or difficulties they are experiencing. The assistance includes procedures to reduce radiation exposure and/or contamination, and practical solutions to problems that may place the authorization in a noncompliant situation.

### RAM Security

Ensuring radioactive material (RAM) security continues to be a significant concern. Always be aware of who is in your laboratory and confront any unfamiliar individuals. Keep RAM locked up or under direct observation at all times to prevent an unauthorized person from removing the RAM or gaining access to the RAM. The last person leaving a RAM–use laboratory should ensure the door to the laboratory is either locked or all of the RAM inside the room, including waste, is locked up.

### ALARA

The ALARA acronym stands for "as low as is reasonably achievable". ALARA means that every radiation worker shall make an effort to keep doses as low as possible even if their annual dose is well below regulatory limits. All these efforts shall be “reasonable” efforts.

The three primary methods to reduce or avoid radiation exposure relate to the appropriate application of time, distance and shielding:

- **Time**: Reducing the amount of time an individual is in a radiation field decreases the radiation dose. This can be accomplished by removing the individual from the radiation field and performing procedures around a radiation field quickly and accurately.
- **Distance**: Increasing the distance from a radiation source can greatly reduce the exposure. Moving outside the range of a beta emitter (e.g., moving 20 feet away from a $^{32}$P source) will eliminate all radiation exposure because of the shielding provided by the air. For photon emitters (gamma or x-ray) the air provides essentially no effective shielding; however, because photon radiation travels out of the radiation source in primarily straight lines, the density of photons from a point source will drop by a square function as the distance increases. What this means is if a person is 1 foot from a point source and is receiving a dose of 100 mrem/hr, by simply moving to 2 feet away the dose is lowered by a factor of $2^2$ to 25 mrem/hr.
- **Shielding**: It is often not possible to increase the distance from or significantly reduce the work time with a radiation source when working with radioactive material. In these cases shielding is used to reduce the dose received from the radiation source. It is important to use appropriate shielding.
  - ♦ Lead for gamma emitters.
  - ♦ Plastic for beta emitters.

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