Radiation Safety Training for General Users & Ancillary Personnel

Prepared by: Maksudur R. Sarder, RSO
Presented by: Carla Spencer, ARSO
EH&S, Facilities Management Dept.
University of Arkansas
521 South Razorback Road, Fayetteville, Arkansas
Phone: 575-3379
Course Objectives

• To provide basic radiation hazards, safety and policy information
Ionizing radiation causes cancer, birth defects and genetic mutations.

Following the discovery of x-rays and natural radioactivity in the early twentieth century, many early researchers and radiologists succumbed to radiation-induced leukemia and other cancers.
Mission of the Radiation Safety Program

• To assist users in keeping radiation exposures to a minimum;

• To assist the University in complying with state and federal regulations concerning radioactive materials use;

• To provide instruction to workers regarding the safe use of radioactivity.
Who are General Users?

General users personnel are University employees or contractors whose duties do not involve direct use of radioactive materials and/or radiation devices but who may require occasional entry into areas where those materials and/or devices are used and who may also require occasional encounter with radiation concerns.
Who are Ancillary Personnel?

Ancillary personnel are University employees or contractors whose duties do not involve direct use of radioactive materials and/or radiation devices but who may require occasional entry into areas where those materials and/or devices are used. For example: UAPD, custodial staff
UA Radiation Protection - Chain of Responsibility

- State/Federal oversight of radioactivity
- UA administration (Chancellor, Provost)
- Radiation safety committees
- Radiation Safety Officer
- Authorized Radiation Users
- Individual laboratory workers, general users, ancillary personnel
Radiation and Radioactivity

- **Radiation** is energy in transit, either as particles or electromagnetic waves.
- **Radioactivity** is the characteristic of various materials to emit ionizing radiation.
Ionization

- Ionization is the removal of electrons from an atom.
- Ionization is the essential characteristic of high energy radiations when interacting with matter.
Dose Unit

• The **Rad** is a unit for measuring the absorbed energy from radiation

• The **Rem** is a unit for measuring the biological damage caused by that radiation
Millirem

Doses encountered in every day life are typically much less than a rem. As a result, doses are usually expressed in terms of thousandths of a rem, or millirem (mrem).
Background Radiation

• How much radiation dose do we receive if we are not occupationally exposed?

• The average person in the United States receives about 360 millirem every year (whole body equivalent dose).

• This dose is mostly from natural sources of radiation.
## Typical Annual Radiation Exposures to a Citizen of the US.

<table>
<thead>
<tr>
<th>Source</th>
<th>mrem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inhaled (radon &amp; its progeny)</td>
<td>200</td>
</tr>
<tr>
<td>Other internal (K-40)</td>
<td>39</td>
</tr>
<tr>
<td>Terrestrial</td>
<td>28</td>
</tr>
<tr>
<td>Cosmic</td>
<td>27</td>
</tr>
<tr>
<td>Cosmogenic</td>
<td>1</td>
</tr>
<tr>
<td>Medical X-ray</td>
<td>60</td>
</tr>
<tr>
<td>Total</td>
<td>~ 360</td>
</tr>
</tbody>
</table>
## Regulatory Limits in mrem

<table>
<thead>
<tr>
<th>Occupational Category</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupational Whole Body Dose Equivalent</td>
<td>5,000 mrem/year</td>
</tr>
<tr>
<td>Occupational Whole Body Dose Equivalent (Minors)</td>
<td>500 mrem/year</td>
</tr>
<tr>
<td>Fetus</td>
<td>500 mrem/9 months</td>
</tr>
<tr>
<td>Member of Public</td>
<td>100 mrem/year</td>
</tr>
<tr>
<td>Occupational Eye Dose Equivalent</td>
<td>15,000 mrem/year</td>
</tr>
<tr>
<td>Occupational Skin or Extremity</td>
<td>50,000 mrem/year</td>
</tr>
</tbody>
</table>
Ancillary Personnel

• Are considered members of the public.

• Do not receive personnel monitoring devices.

• Are limited to less than 100 mrem per year above background.
ALARA Principle

- UA radiation safety activities strive to keep all radiation doses associated with University activities well below the regulatory limits and As Low As Reasonably Achievable (ALARA).
Where can Lab Radiation Sources be Found?

On a campus as large and complex as UA's, radiation sources can pop up anywhere.

From a standpoint of controlling inventory and security, it is important to know where sources can be hiding:

- liquid scintillation counter external "quench" sources
- gas chromatographs
- soil moisture gauges
- materials thickness gauges
- smoke detectors
- static electricity dissipation units
Recognize a Room that Contains Radioactive Materials

- Look for a yellow and Magenta radiation sign as shown here
- You should contact the Authorized users listed before doing any work in the laboratory
- No smoking, eating, drinking in the laboratory
Recognize a Package that Contains Radioactive Materials

- Look for the DOT shipping labels on the package and boxes containing radioactive materials
- Do not remove the labels
- Do not dispose of, move, or remove the boxes or other containers containing the labels
Encountering Equipment that Contains Radioactive Materials

- **Do not** attempt to move, remove, or service any piece of equipment with this sign.
- Do not discard any item that displays this sign.
- If you have any concerns, please contact authorized user of the equipment, or the Radiation Safety Officer at 575-3379.
Recognize a Room Contains X-ray

- Look for a label or metal plate attached to the equipment similar to the one shown here
Working in a Room Containing X-ray Equipment

- Contact the Authorized user for Safety instructions
- Ensure that the equipment is off before working around it
Types of Ionizing Radiation

- X-ray -- photon from the electron shell
- Gamma ray -- photon from the nucleus
- Alpha particle -- a helium nucleus
- Beta particle -- an electron or positron
- Neutrons
Sources of Ionizing Radiation

- Cosmic rays and naturally-occurring radioactive elements (natural background)
- Medical x-rays and nuclear medicine studies
- Man-made radioactive materials and radiation sources
Gamma rays (such as from I-125, Na-22 or Cr-51) require lead or tungsten as a shielding material.

Neutrons are not effectively shielded by lead; they require high-proton materials such as water, paraffin or concrete.

High energy (>250 keV) betas (e.g. from P-32) should be shielded by Plexiglas to minimize Bremstrahlung X-rays.
Radioactive Materials Security

Each year, radioactive materials are stolen from campus labs across the country - often by people who are unaware of what they are stealing.

Federal and state laws are clear on this matter: radioactive materials that are not actively in use shall be locked up.

Radioactive materials shall not be left unattended on lab bench tops. Unauthorized personnel must be excluded from labs -- by the police, if necessary.
There are two types of radiation bioeffects - deterministic and stochastic.

**Deterministic**
- Severity increases with radiation dose
- Threshold: 50-100 rem
- Dose and dose rate dependent
- Examples
  - Cataract induction
  - Epilation (hair loss)
  - Erythema (skin reddening)
  - Blood changes
Stochastic

• Probability of occurrence increases with radiation dose
• Threshold: 10 rem, but regulatory models assume no threshold (ALARA!)

Examples

• Cancer induction
• Genetic mutations
• Developmental abnormalities
## Deterministic Radiation Effect Thresholds

<table>
<thead>
<tr>
<th>HEALTH EFFECT</th>
<th>ORGAN</th>
<th>DOSE (rem)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temporary sterility</td>
<td>Testis</td>
<td>15</td>
</tr>
<tr>
<td>Nausea</td>
<td>GI</td>
<td>35</td>
</tr>
<tr>
<td>Blood cell depression</td>
<td>Bone marrow</td>
<td>50</td>
</tr>
<tr>
<td>Reversible skin effects</td>
<td>Skin</td>
<td>200</td>
</tr>
<tr>
<td>Permanent sterility</td>
<td>Ovaries</td>
<td>250 - 600</td>
</tr>
<tr>
<td>Vomiting</td>
<td>GI</td>
<td>300</td>
</tr>
<tr>
<td>Temporary hair loss</td>
<td>Skin</td>
<td>300 - 500</td>
</tr>
<tr>
<td>Permanent sterility</td>
<td>Testis</td>
<td>350</td>
</tr>
<tr>
<td>Skin erythema</td>
<td>Skin</td>
<td>500 - 600</td>
</tr>
</tbody>
</table>
Types of Radiation Exposure

• **External** - from gamma photons, x-rays or high-energy beta particles emitted from a source outside the body

• **Internal** - from sources inside the body, which presumably came to be there following ingestion or inhalation of contamination
Radionuclides that represent trivial external hazards, such as carbon-14 or tritium, can become significant internal hazards if ingested.

**Do Not Ever:**
- pipette radioactive materials by mouth suction
- smoke in the labs
- eat or drink in the labs
- apply cosmetics in the labs
- leave radioactive materials unattended

In general, keep your hands away from your mouth, eyes and other mucosal surfaces.
Protection Against Internal Exposure

- Awareness of the hazard
- Good laboratory technique
- Use of personal protective equipment (ppe) such as gloves, lab coats and fume hoods
- Proper and timely performance of surveys for radioactive contamination
Protection Against External Exposure

• The three important factors in protecting against external exposure are **time**, **distance** and **shielding**.

• Judicious use of a combination of these factors can minimize radiation exposure.
Low-energy beta emitters (<250 keV), such as C-14 and H-3, are stopped in a few centimeters of air and require no shielding.

High-energy betas (>250 keV) like P-32 require several millimeters of plastic to stop. Avoid using bare lead to shield P-32, since secondary x-rays (Brehmstrahlung) are produced.
Personnel dosimeters (film badges) are issued by the Radiation Safety Division to document your occupational exposure.

Depending on what you work with, you may or may not need one:

- Labs using H-3, C-14, P-33, S-35 and/or Ca-45: no monitoring required
- Labs using P-32: a finger ring dosimeter is required
- Labs using Cr-51, I-125, I-131, other gamma emitters and/or analytical x-ray equipment: whole body dosimeter is required
Obtaining a Dosimeter

- Order one (contact RSO/AU)
- Obtain and complete a "Personnel Dosimeter Request and Radiation Exposure History" form

If you have had previous employment involving radiation exposure, you must complete a release form.
Lost Dosimeter

- Contact the Radiation Safety Officer
- Obtain and complete "Certificate of Lost Badge" form
- Another dosimeter will be ordered
- Yearly average dose will be assigned to your record
Pregnant Female

- State regulatory limit to the embryo/fetus is 500 mrem for entire gestation period
- If pregnant, a confidential reproductive health consultation is available
- A fetal dosimetry badge will be ordered, if necessary
How to Correctly Wear Your Badge

Whole body badges should be worn between the neck and the waist.

Ring badges can be worn on any finger. The badge should be on the inside of your palm, facing the radioactive work.
1. Notify other persons in the area of the spill.
2. Evacuate if spill is of a volatile material.
3. Immediately remove contaminated shoes or clothing.
4. Mark the spill area and limit access to avoid the inadvertent spread of contamination.
5. Flush contaminated skin thoroughly with water.
6. Notify the Radiation Safety Officer, EH&S.
What you have to do if you put radioactive waste in regular trash!

Always dispose of radioactive materials properly.
Questions/Comments about Radioactive Waste Disposal

Contact Maksudur Sarder or Carla Spencer.

• phone number: 575-3379 or 575-5336
• email: msarder@uark.edu
cspencer@uark.edu