Radiological Preparedness & Emergency Response

Session II

Basic Radiation Physics

Objectives
- Discuss the difference between ionizing and non-ionizing radiation.
- Describe radioactive decay.
- Discuss the different types of ionizing radiation.
Radiation in Pop Culture

Different Types of Radiation

Non-ionizing
- Electromagnetic waves (EM waves)
- Radio waves
- Microwaves
- Infrared
- Ultraviolet
- X-rays
- Gamma rays

Ionizing
- Alpha particles
- Beta particles
- Gamma rays
- X-rays
- Nuclear decay

Non-thermal effects
- Induces low currents
- Induces high currents
- Heating
- Breaking bonds
- Damages DNA

Thermal effects
- Heating
- Photochemical effects
- Radiation sickness

Examples of non-ionizing radiation:
- AM radio
- FM radio
- Microwaves
- Heat lamps
- Tennis rackets
- Medical x-rays

Examples of ionizing radiation:
- Alpha particles
- Beta particles
- Gamma rays
- X-rays
- Nuclear decay
Ionizing Radiation

- Damages DNA.
- Produces free radicals by damaging water molecules.

Radiation Damage

- Deterministic
  - Threshold dose
  - Local radiation injury
  - Acute radiation syndrome
- Stochastic
  - Random
  - Oncogenesis
  - Teratogenesis

Cell Sensitivity

- **High**
  - Embryos!!!
  - Blood-forming organs (numbers).
  - Cancer cells / tumors.
  - GI tract.
  - Skin (including hair follicles).
  - Muscles.
- **Low**
  - Central nervous system.
What is an Atom Composed Off?

Why do Certain Atoms Emit Radiation and are Radioactive?

Example of an Alpha Particle Emitter: Polonium-210

- Alpha particles
  - Positively charged, easily stopped by a thin paper, do not present an external hazard.
  - Inhaled/ingested, can result in significant organ damage.

http://www.blackcatsystems.com/science/radprod.html
**Example of a Beta Particle Emitter: Carbon-14**

- Beta particles
  - Negatively charged electrons, can travel several centimeters through air. Stopped by clothes.
  - If internalized can cause problems.
  - "beta burn".

**Example of a Gamma Ray Emitter: Cesium-137**

- Gamma rays
  - Electromagnetic waves.
  - Gamma rays are the same as x-rays -- the difference is their source from within the atom: nuclear for gamma, extranuclear for X-rays.
  - Are a significant hazard (depending on duration of exposure, distance from the source, and type of shielding).

**Example of a Neutron Emitter: Uranium-235**

- Neutrons
  - Neutron irradiation can turn previously nonradioactive materials radioactive.
  - Uncharged. Causes whole body irradiation like Gamma rays.
  - Emitted from fission reactions.
Differences

CDC Video

Radiation Measurement Units

<table>
<thead>
<tr>
<th>S.I.</th>
<th>Formula</th>
<th>USA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Becquerel (Bq)</td>
<td>$1/3.6 \times 10^{10}$ x</td>
<td>Curie (Ci)</td>
</tr>
<tr>
<td>1 Gray (Gy)</td>
<td>100 x</td>
<td>RAD</td>
</tr>
<tr>
<td>1 Sievert (Sv)</td>
<td>100 x</td>
<td>REM</td>
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</tbody>
</table>
Difference Between RAD and REM - Gray and Sievert

- RAD and Gray express the amount of energy deposited per gram of tissue or material.
- REM and Sievert express the health effect from the radiation deposited in a specific organ by a specific type of radiation.
- For gamma rays 1 RAD = 1 REM.

What is a Radiation Source Activity?

- Activity reflects how radioactive a source is.
- How many disintegrations or decays are occurring every second.
- As time passes, a radioactive source is no longer radioactive.
- The amount of time needed depends on the source radiological half life.

Physical Half Life

- Time required for activity to be reduced by ½.
- Specific to each radionuclide
  - I-131 = 8 day
  - Cs-134 = 2 yr
  - Cs-137 = 30 yr
Biological and Effective Half-Life

- Biological: time required for body to eliminate ½ of a particular element
- Effective: combined effect of radioactive decay and physical elimination
- Effective half-life is ALWAYS less than physical or biological half-life

Where is Radiation Found?

- Natural sources
  - Radon
  - Cosmic rays
- Man-made sources

Radon Map Georgia
Background Radiation

People on Earth Are Exposed to Radiation Every Day of Their Life

In 2006, the average person in the United States received an annual radiation dose of 2.2 millionths.

<table>
<thead>
<tr>
<th>Source of Radiation</th>
<th>Percent Contribution to Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical Sources/Medical</td>
<td></td>
</tr>
<tr>
<td>Dent (Radiography)</td>
<td>X</td>
</tr>
<tr>
<td>Inhaled Radioactive</td>
<td>1/10</td>
</tr>
<tr>
<td>(Background)</td>
<td></td>
</tr>
<tr>
<td>Personal Background</td>
<td>2/10</td>
</tr>
<tr>
<td>Medical procedures</td>
<td></td>
</tr>
<tr>
<td>Consumer sources</td>
<td>9/10</td>
</tr>
<tr>
<td>Industrial sources</td>
<td>1/10</td>
</tr>
<tr>
<td>Uranium-235</td>
<td>2/10</td>
</tr>
</tbody>
</table>

NCRP Report No. 160, Ionizing Radiation Exposure of the Population of the United States

ALARA

- “As Low As Reasonably Achievable”
- Work activities in radiation areas must be carefully planned to minimize radiation doses to workers
- Dose to general public kept low
- Control of releases of radioactive materials to the environment
Summary Points

- Ionizing radiation damages cells and DNA.
- Ionizing radiation includes alpha particles, beta particles, gamma rays and neutrons.
- People are exposed to background radiation at all times.

Any Questions?