Radioactive Materials Emergencies

Radiation Fundamentals for Firefighters

Student Handout

Prepared by Hanford Fire Department Training Group
(509)373-2123
Objectives

– To understand the hazards of responding to events involving radioactive materials
– To know the fundamentals of radioactive contamination
– To understand the biological affects of exposure to radioactive materials
– To know how to respond to hazmat events involving radioactive materials
RADIOLOGICAL TERMS

• CURIE (Ci)
  - The basic unit of activity. A quantity of any radionuclide that undergoes an average of 37 billion transformations per second.
  - One curie is the approximate activity of 1 gram of radium.
  - Named after Marie and Pierre Curie, who discovered radium in 1898
• **Rad (radiation absorbed dose)**-
  
  – Measures a quantity called “absorbed dose” which means the amount of energy actually absorbed in a material.

  – The rad measures any type of radiation, but it does not describe the biological effects.
• **Rem (roentgen equivalent man)**-
  – Measures a quantity called “equivalent dose” which relates the absorbed dose in human tissue to the resulting biological damage.
  – This measurement is necessary because not all radiation has the same biological effect.
  – The rem measurement is obtained by measuring the rad and multiplying it by a quality factor that is unique to a specific type of radiation.
• **Roentgen (R)**-
  - A unit of exposure to ionizing radiation.
  - It is the amount of gamma or x-rays required producing ions carrying 1 electrostatic unit of electrical charge in 1 cubic centimeter of dry air under standard conditions.
  - Named after Wilhelm Roentgen, German scientist who discovered x-rays in 1895.
# SYSTEME INTERNATIONAL

<table>
<thead>
<tr>
<th>Traditional Unit</th>
<th>SI Unit</th>
<th>Conversion Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curie (Ci)</td>
<td>Becquerel (Bq)</td>
<td>1 Ci = 37 Billion Bq</td>
</tr>
<tr>
<td>Rad</td>
<td>Gray (Gy)</td>
<td>1 Gy = 100 Rad</td>
</tr>
<tr>
<td>Rem</td>
<td>Sievert (Sv)</td>
<td>1 SV = 100 Rem</td>
</tr>
<tr>
<td>Roentgen (R)</td>
<td>Coulombs per kilogram (C/kg)</td>
<td>1 R = 25800 C/kg</td>
</tr>
</tbody>
</table>
## Radiation from Natural Sources

<table>
<thead>
<tr>
<th>Source</th>
<th>mrem/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cosmic rays</td>
<td>28</td>
</tr>
<tr>
<td>The earth</td>
<td>26</td>
</tr>
<tr>
<td>Radon</td>
<td>200</td>
</tr>
<tr>
<td>The human body</td>
<td>25</td>
</tr>
<tr>
<td>Building materials</td>
<td>4</td>
</tr>
<tr>
<td>Source</td>
<td>mrem/year</td>
</tr>
<tr>
<td>------------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>Medical</td>
<td>90</td>
</tr>
<tr>
<td>Fallout</td>
<td>5</td>
</tr>
<tr>
<td>Consumer products</td>
<td>1</td>
</tr>
<tr>
<td>Nuclear power</td>
<td>0.3</td>
</tr>
</tbody>
</table>
### Radioisotopes used in Medicine and Industry

<table>
<thead>
<tr>
<th>Isotope</th>
<th>Example of Uses</th>
<th>Form for Shipping</th>
<th>Mode of Transport</th>
</tr>
</thead>
<tbody>
<tr>
<td>Americium 241</td>
<td>Used in Industry to:</td>
<td>Powder (enclosed in a capsule)</td>
<td>Highway, Rail, Air</td>
</tr>
<tr>
<td></td>
<td>• Determine oil well drill locations</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>• Smoke detectors</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Measure lead in dried paint</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Ensure uniformity in steel and paper production</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Californium 252</td>
<td>Used in Medicine to:</td>
<td>Solid</td>
<td>Highway, Air</td>
</tr>
<tr>
<td></td>
<td>• Research and treat cancer (especially cervical, ovarian and brain cancers)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cobalt 60</td>
<td>Used in Medicine to:</td>
<td>Solid</td>
<td>Highway, Rail, Air</td>
</tr>
<tr>
<td></td>
<td>• Treat Cancer</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Suppress immune reaction in transplants</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Sterilize surgical instruments</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Used in Industry to:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Test welds and castings</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Check for internal structural flaws</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Locate buried utility lines</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Used in Agriculture to:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Preserve poultry, fruits and spices</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iodine 131</td>
<td>Used in Medicine to:</td>
<td>Solid</td>
<td>Highway, Rail, Air</td>
</tr>
<tr>
<td></td>
<td>• Diagnose and treat medical disorders</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Trace medical observations</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Atoms

Elements are defined by the number of protons

- Red = Proton
- Blue = Neutron

Hydrogen - 1 Proton
Helium - 2 Protons
Carbon - 6 Protons

1. What elemental nuclei are these?

2. How many neutrons does Carbon 60 have?

3. How many neutrons and protons does Carbon 13 have?

Answers:
1. Because they have only one proton, all these nuclei are different isotopes of hydrogen
2. Carbon 60 has 54 neutrons (plus 6 protons)
3. Carbon 13 has 7 neutrons and 6 protons
The nucleus contains positively charged protons and neutrons, which are not charged.

Orbiting electrons are negatively charged.

When the number of protons and electrons are equal, charges are balanced and the atom is stable.
An electron can be knocked from its orbit

The atom becomes charged, or “ionized”
TYPES OF RADIATION

• ALPHA PARTICLES
• BETA PARTICLES
• GAMMA RAYS
• X-RAYS
• NEUTRONS
ALPHA PARTICLE
BETA PARTICLE
GAMMA RAY
X-RAY
NEUTRONS
Acute vs. Chronic Effects

Length of Effect

Length of Exposure

Acute

Chronic
Stages of Acute Radiation Syndrome

- Nausea, vomiting
- White blood cells affected
- Death within weeks or days

Graph showing the progression of radiation symptoms with increasing radiation dosage (R).
## DOSE LIMITS

### Table 1.4 Dose Limits for Emergency Workers

<table>
<thead>
<tr>
<th>Rem</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>General monitoring (no life safety involved)</td>
</tr>
<tr>
<td>10</td>
<td>Protection of a large population</td>
</tr>
<tr>
<td>25</td>
<td>Life saving (once in a lifetime)</td>
</tr>
<tr>
<td>&gt;25</td>
<td>Life saving (authorization required)</td>
</tr>
</tbody>
</table>

Source: U.S. EPA 400 1994

For exposures above 25 rem, responders must be fully aware of the risks involved, and the person or agency in command must authorize in writing.
Precautions for Radiation Hazards

- Time
- Distance
- Shielding
INVERSE SQUARE LAW

- Source 1 ft.
- 400 mR/hr
- 2 ft.
- 100 mR/hr
- 4 ft.
- 25 mR/hr
Placards/Labels for Radioactive Materials

Radioactive white - I
Contains almost no radiation
(0.5 mR/hr on surface)

Radioactive yellow - II
Low radiation levels (50 mR/hr maximum on surface; 1 mR/hr maximum at 1 meter)

Radioactive yellow - III
Higher radiation levels (200 mR/hr maximum on surface; 10 mR/hr maximum at 1 meter)

Transparency 5-1
## Radiological Shipments by Industry

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>54.5%</td>
<td>10.7%</td>
<td>6%</td>
<td>1.8%</td>
<td>0.2%</td>
<td>14.8%</td>
<td>12%</td>
</tr>
</tbody>
</table>
Radiological Shipments by Industry

- Medical: 62%
- Industrial: 26%
- Other: 12%

“Other” includes fuel rods, fissile materials, utility waste, and military shipments
“Other” includes ship, private motor carrier, and parcel and freight forwarders.
Routes of Exposure: Direct Contact

Chemicals can enter directly through the skin...

…or through hair follicles

Epidermis

Dermis

Subcutaneous Tissue

Skin
Routes of Exposure: Inhalation

- Pharynx
- Trachea
- Bronchii
- Bronchiole

Respiratory System
Routes of Exposure: Ingestion

- Mouth
- Pharynx
- Esophagus
- Liver
- Stomach
- Large Intestine
- Small Intestine

Digestive System
Patients exposed to external sources of radiation do not pose contamination problems.
Externally-contaminated patients should be checked with radiation meters and given on-scene emergency care ASAP.

Transparency 6-2
Internally-contaminated patients must be given medical care for injuries but there is little you can do to treat radiation exposures.