Radioactive Waste Disposal

Reading
• Today: Ch 15 (386-396)
• Next Monday: Ch 14 (348-363)

Radioactive Decay
Half-lives, Activity, Decay Products

<table>
<thead>
<tr>
<th>Radi nuclid e</th>
<th>Half-life</th>
<th>Activity</th>
<th>Products</th>
<th>Decay Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>tritium (3H)</td>
<td>12.3 yrs</td>
<td>9,800 Bq</td>
<td>γ</td>
<td>18.6 keV</td>
</tr>
<tr>
<td>carbon-14</td>
<td>5,730 yrs</td>
<td>4.5 Bq</td>
<td>γ</td>
<td>156.5 keV</td>
</tr>
<tr>
<td>iodine-131</td>
<td>8 days</td>
<td>125,000 Bq</td>
<td>γ</td>
<td>971 keV</td>
</tr>
<tr>
<td>iodine-129</td>
<td>16 min</td>
<td>0.000175 Bq</td>
<td>γ</td>
<td>193 keV</td>
</tr>
<tr>
<td>strontium-90</td>
<td>29 yrs</td>
<td>130 Bq</td>
<td>α</td>
<td>548 keV</td>
</tr>
<tr>
<td>uranium-235</td>
<td>7,040 yrs</td>
<td>0.0000032 Bq</td>
<td>γ</td>
<td>4,679 keV</td>
</tr>
<tr>
<td>plutonium-239</td>
<td>24,110 yrs</td>
<td>0.063 Bq</td>
<td>αγ</td>
<td>5,244 keV</td>
</tr>
</tbody>
</table>

Short half-life, high activity
Activity measured in curies
1 curie = 37 billion
disintegrations per second
Equal to activity of 1 gram of radium

Health Effects of Radiation
Dose and Response

Doses to humans measured in rems (or mrems = 0.001 rem)

Health effects can be "acute" due to high exposure

<table>
<thead>
<tr>
<th>Exposure</th>
<th>Effect</th>
<th>Onset</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 rem</td>
<td>nausea</td>
<td>hours</td>
</tr>
<tr>
<td>75 rem</td>
<td>hair loss</td>
<td>2-3 weeks</td>
</tr>
<tr>
<td>400 rem</td>
<td>death</td>
<td>2 months</td>
</tr>
<tr>
<td>2000 rem</td>
<td>death</td>
<td>hours-days</td>
</tr>
</tbody>
</table>

“Stochastic” effects of lower doses, for example increased risk of cancer

Background Exposures

Normal annual exposure from natural radiation
About 360 mrem/yr

- Radon gas
- Lunar body
- Rocks, soil
- Cosmic rays

Normal annual exposure from man-made radiation
About 70 mrem/yr

- Medical procedures
- Consumer products
- One round of non-flight
- Striking coil or TV
- Sleeping with wood or person
- Weapon test fallout
- Nuclear accident
Classes of Radioactive Waste

**Transuranic Waste**
- Higher atomic number than U (includes plutonium)
- Contaminated clothing, tools etc. from defense and nuclear power plants
- Mostly low activity due to low concentrations, long half-lives

**Low Level Waste**
- 3 operating sites
- State compacts – none have approved a new site

**Transuranic Waste**
- The Waste Isolation Pilot Plant (WIPP)
  - Near Carlsbad NM
  - Mined repository in bedded salt
  - Opened in 1999 after 20 years of study and legal challenges

**High Level Waste**
- Spent fuel
- Defense waste
Yucca Mountain (Video)

Evaluating Future Risks
“Performance Assessment”

- Information on how natural and engineered barriers will work together to contain and isolate waste
- Information about features, events, and processes that could affect the repository’s ability to isolate waste
- Results of how the repository would likely perform in the future based on a total system performance assessment

Release and Transport in the “Undisturbed” Case

- Climate and Unsaturated Zone Processes
- Saturated Zone Processes

Transport Uncertainties for the “Undisturbed” Case

- Regional Flow Directions
- Wide, low concentration plume
- Narrow, high concentration plume
Human Uncertainties for the "Undisturbed" Case

Future human activities - impossible to predict, so must specify a "plausible" maximally exposed individual.

Disruptive Events

Deep well dilutes concentration
Shallow well yields high concentration

Yucca Mountain Timeline and Current Status

1. EPA sets the "standard"
40 CFR Part 197 issued in July 2001
Maximum added dose of 15 mrem/year to an individual
Time frame: 10,000 years

2. Nuclear Regulatory Commission develops licensing criteria to implement the EPA standard
Issued 2001, amended 2002

3. Secretary of Energy must recommend and President must approve site – July 2002

3. Department of Energy submits license application for constructing the repository
Scheduled for late 2004

4. NRC has three years to review and rule on construction authorization

5. Final licensing after construction, prior to waste emplacement

Disruptive Events

Human Intrusion

Warnings unlikely to last or be meaningful in 100s or 1000s of years

Yucca Mountain Anomaly A

Disruptive Events

Selenic Events