IV. Standard Protective Measures Against Ionizing Radiation

Robert E. Reiman, MSPH, MD, Duke University Medical Center

Center for Medical Countermeasures Against Radiation
Objectives

• Understand the principal of “ALARA”.
• Understand how administrative controls are useful in the protection of personnel against radiation.
• Learn standard procedural and engineering controls that are effective in reducing radiation exposure.
Guiding Principals

• No unnecessary exposure to radiation.

• Principal of “ALARA”
Principle of “ALARA”

As Low As Reasonably Achievable
“ALARA” policies strive to keep radiation exposure to the lowest feasible levels, within societal and economic constraints. A radiation protection program consistent with ALARA maintains radiation exposures at 10% or less of the applicable regulatory limits.
Administrative Controls: Radiation Regulations

Code of Federal Regulations, Title 10, Parts 20 and 35 set occupational dose limits and provide for protection of the general public.
# Annual Radiation Dose Limits

<table>
<thead>
<tr>
<th>Population</th>
<th>NCRP 91</th>
<th>10 CFR 20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rad. Workers</td>
<td>5/15/50 rem</td>
<td>5/15/50 rem</td>
</tr>
<tr>
<td></td>
<td>1 x age lifetime</td>
<td>No Lifetime</td>
</tr>
<tr>
<td>Occasion. Exposed</td>
<td>0.5/5/5 rem</td>
<td>0.5 rem</td>
</tr>
<tr>
<td>Gen. Public</td>
<td>0.5/5/5 rem</td>
<td>0.1 rem</td>
</tr>
<tr>
<td>Minor Trainees</td>
<td>0.1 rem</td>
<td>0.5 rem</td>
</tr>
<tr>
<td>Fetus</td>
<td>0.5 rem</td>
<td>0.5 rem</td>
</tr>
<tr>
<td></td>
<td>50 mrem / month</td>
<td>No monthly limit</td>
</tr>
</tbody>
</table>
Occupational Exposure

Does NOT Include:

• Natural background radiation / radon.
• Medical x-rays or nuclear medicine studies.
• Anything else not directly consequential to employment or to activities of regulated licensees.
Administrative Controls: Posting

> 5 mrem/hr  > 100 mrem/hr  > 500 rem/hr

Depends on radionuclide: > 10 mCi H-3, 1 mCi S-35, 0.1 mCi P-32, 0.001 mCi I-125
External Radiation Dosimetry

- Accomplished by wearing “personal dosimeters” on the body surface.
- Dosimeter measures the dose to the dosimeter, not to the individual wearing it.
- Dose to personnel must be estimated from the dosimeter’s reading.
Internal Radiation Dosimetry

• “Bioassays” can provide important physiological information for internal dosimetric purposes:
  – Assay of thyroid radioactivity (radioiodine)
  – Urine assay (tritium, heavy metals)
  – Total body counting (limited availability)
Procedural Controls

- Individuals can limit exposure to radiation by modifying the way they work around radiation sources or radioactive materials.
- The major procedural controls against radiation are **time**, **distance** and **shielding**.
• **Total exposure** is the product of exposure rate and time
• Therefore, reduction in time of exposure reduces total exposure and consequently total absorbed dose
• SO...work *quickly* but *safely*
Time - Distance - Shielding

1 meter:  16.0 mR / hr
2 meters:  4.0 mR / hr
3 meters:  1.8 mR / hr
4 meters:  1.0 mR / hr
Soft betas from C-14 and tritium are stopped in glassware. P-32 beta is stopped by 3-5 mm Lucite. Heavy metals are required to stop gammas.
Half Value Layer (HVL)

- Is the thickness of a shielding material required to reduce the transmitted exposure rate (R) to one-half the incident exposure rate (R₀).
- HVL depends upon the material’s atomic number and density, and upon the energy spectrum of the incident photons.
Attenuation of Photons by Shielding

\[ R = R_0 \left( \exp \left( -0.693 \frac{t}{HVL} \right) \right) \]

- \( R \) = Attenuated exposure rate
- \( R_0 \) = Primary Exposure Rate
- \( t \) = thickness of shielding (cm)
- \( HVL \) = “Half Value Layer” (cm)
<table>
<thead>
<tr>
<th>Energy (kVp)</th>
<th>Lead (cm)</th>
<th>Concrete (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>0.005</td>
<td>0.432</td>
</tr>
<tr>
<td>70</td>
<td>0.015</td>
<td>0.838</td>
</tr>
<tr>
<td>100</td>
<td>0.024</td>
<td>1.524</td>
</tr>
<tr>
<td>125</td>
<td>0.027</td>
<td>2.032</td>
</tr>
<tr>
<td>150</td>
<td>0.029</td>
<td>2.235</td>
</tr>
</tbody>
</table>
“Rule of Thumb: Shadow Shield provides maximum reduction of about 1 part in 400
Lead aprons must contain shielding equivalent to 0.5 mm thickness of lead. The “wrap-around” type affords increased protection from scattered radiation. Light-weight, non-lead aprons are available.
PPE -- Collars and Glasses

Shielding collars and leaded glasses protect the thyroid gland and the lens of the eye from ionizing radiation.
PPE -- Shielding Gloves

Shielding gloves shall be worn if the hands are placed in the useful (primary) x-ray beam.
Controlling Contamination

- Cover work surfaces
- Wash hands frequently
Controlling Contamination

- Don’t Drink
- Don’t Eat
- Don’t Smoke
- No cosmetics
Controlling Contamination:

PPE

- Lab Coats
- Gloves
- Fume Hood
Radiation Survey Instruments
Survey Meter Quality Assurance

- Meters OFF when not in use
- Operation check with each use
- Regular battery and high-voltage checks
- Annual calibration
End of Module IV

- This concludes Module IV.