Radiation Safety Principles

Oak Ridge Associated Universities
Objectives

- Review the basic principles of radiation safety.
- Discuss the application of these principles to various situations.
The principles of radiation safety are simple and easy to learn and remember.

However, it is fundamental that the application of these principles be based on some knowledge or estimate of the radiological conditions.
Introduction

- Many people have learned radiation safety as:
  - *Time (minimize).*
  - *Distance (maximize).*
  - *Shielding (utilize).*

- These principles work for many circumstances, but other principles should be considered.
Introduction

- One of the best summaries of radiation safety principles are the “Ten Principles and Ten Commandments of Radiation Protection” by Daniel Strom.

- This presentation is based on Strom’s principles and commandments.
Goals of Radiation Safety

- **Keep it safe**
  - Prevent deterministic effects
  - Limit probability of stochastic effects

- **Keep it legal**
  - Keep it affordable
  - Be able to prove it

- **Help people feel safe**
#1. Time

- Minimizing the amount of time in a radiation field reduces the dose.
- Hurry, but don’t be hasty.
Time Reduction Methods

- Plan and discuss the task prior to entering the area.
- Use only the number of workers actually required to do the job.
- Have all necessary tools present before entering the area.
Time Reduction Methods

- Use mock-ups and practice runs that duplicate work conditions.

- Take the most direct route to the job site, if possible and practical.

- Never loiter in an area controlled for radiological purposes.
Time Reduction Methods

- Work efficiently and swiftly.

- Perform as much work outside the area as possible or, when practical, remove parts or components to areas with lower dose rates to perform work.

- In some cases, the radiological control personnel may limit the amount of time a worker may stay in an area due to various reasons (*stay time*).
Time Reduction Methods

- If you have been assigned a stay time, do not exceed this time.

- Do it right the first time, in the least amount of time necessary.
#2. Distance

- The distance principle has a purely geometric component.

- For physically small (point) sources, the dose rate is inversely proportional to the square of the distance away.

  - *Stay away from it.*

  - *Stay upwind.*
Inverse Square Law

\[
Dose = \frac{1}{\text{Distance}^2}
\]

Distance = 1 meter

\[
\text{Dose} = \frac{1}{1 \times 1} = 1 \text{ rem}
\]

Intensity sufficient to deliver a 1 rem dose at 1 meter

Distance = 2 meters

\[
\text{Dose} = \frac{1}{2 \times 2} = \frac{1}{4} \text{ rem}
\]

\[
.25 \text{ rem} = \frac{1}{4} \text{ rem}
\]
Inverse Square Law

\[ I_1 d_1^2 = I_2 d_2^2 \]

If the dose rate is 100 mrem/hr at 1 m from a point source, what is the dose rate at 2 m?
Using the Inverse Square Law

\[ I_1 d_1^2 = I_2 d_2^2 \]

\[ I_2 = \frac{I_1 d_1^2}{d_2^2} \]

\[ I_2 = \frac{(100 \text{ mrem/hr})(1 \text{ m})^2}{(2 \text{ m})^2} \]

\[ I_2 = 25 \text{ mrem/hr} \]
Maximizing Distance Methods

- Stay as far away as possible from the source of radiation.
- Be familiar with radiological conditions in the area.
- During work delays, move to lower dose rate areas or exit the area completely during long delays.
- Use remote handling devices when possible.
- At a minimum, use arm's length.
Maximizing Distance Methods
#3. Source Barrier

- For radiation sources such as x-ray machines and photon-emitting radionuclides, a barrier that attenuates the radiation is called a **shield**.

- *Keep it in.*
Typical Photon Shields

- Lead
- Concrete
- Iron
- Depleted uranium
- Leaded glass
Neutron Shields

- Fast Neutrons:
  - Polyethylene
  - Paraffin
  - Water
  - Other proton rich materials

- Slow Neutrons:
  - Boron
  - Cadmium
  - Indium
Beta Shields

- Lucite
- Plastics
- Low atomic number material

- Shields are generally not required for alpha-emitting radionuclides.
Source Barrier Methods

- **Containment** of radioactive material by:
  - Bagging contaminated items.
  - Covering clean surfaces.
  - Covering contaminated surfaces.

- **Minimizing releases** of radioactive material to the environment by:
  - Encapsulation of sources.
  - Containments.
  - Filtration.
#4. Personal Barrier

- This principle involves isolating the person from the radiation or radioactive material.
  - Protective clothing
  - Lead aprons and gloves
  - Respirators

- *Keep it out.*
#4. Personal Barrier
#5. Dispersal

- Dispersal is the way humans have historically managed many waste problems.
- Be cautious in applying this principle....check with regulatory authorities.

- *Disperse it and dilute it.*
#6. Source Reduction

- Simply using the smallest amount of radioactive material possible for a given purpose will reduce dose.

- Managing decay is another example of source reduction.

- Use as little as possible

- Clean it up

- Keep it clean

- Delay for decay
#6. Source Reduction

Storing waste for decay.
#7. Decorporation

- Decorporation is the removal of radioactive material from the interior or surface of the body, or the blocking of uptakes from systemic circulation by specific tissues or organs.

- *Get it out or off of you.*
Decorporation Methods

- Washing
- Debridement (cleaning a wound)
- Chelating agents
- Forcing fluids for tritium intakes
- Blocking tissue uptake (KI for iodine intakes)
- Surgery
#8. Effect Mitigation

- An *antidote* for radiation exposure is *not known to exist*, and is unlikely to be found given the current state of understanding (Strom pg.392).

- Some possible effect mitigators are *free-radical scavengers* and agents that *reduce oxidative damage*.
Mitigation Methods

- Avoidance of acute effects may be obtained by spreading the dose out over time to allow for repair.

- Spreading dose out over a group of people instead of a few may also mitigate effects to individuals.

- Limit the damage.
#9. Optimal Technology

- Using or modifying a radiation technology to produce a lower dose.

- Optimizing an existing technology.  

- Choose the best technology.
#10. Limitation of Other Exposures

- This principle involves limiting exposures to other agents that may *work in concert* with ionizing radiation. *Don’t compound risks.*

- Examples of these would be agents that could cause tumor:
  - Initiation.
  - Promotion.
  - Progression.
<table>
<thead>
<tr>
<th>Principle</th>
<th>Commandment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>Hurry, but don’t be hasty</td>
</tr>
<tr>
<td>Distance</td>
<td>Stay away/upwind</td>
</tr>
<tr>
<td>Source Barrier</td>
<td>Keep it in</td>
</tr>
<tr>
<td>Personal Barrier</td>
<td>Keep it out</td>
</tr>
<tr>
<td>Source Reduction</td>
<td>Use as little as possible</td>
</tr>
<tr>
<td>Dispersal</td>
<td>Disperse and dilute</td>
</tr>
<tr>
<td>Decorporation</td>
<td>Get it out/off</td>
</tr>
<tr>
<td>Effect Mitigation</td>
<td>Limit damage</td>
</tr>
<tr>
<td>Optimal Technology</td>
<td>Choose best technology</td>
</tr>
<tr>
<td>Limit Other Exposures</td>
<td>Don’t compound risks</td>
</tr>
</tbody>
</table>
References