

# Radiation Safety Principles



Oak Ridge Associated  
Universities

# Objectives

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- Review the basic principles of radiation safety.
- Discuss the application of these principles to various situations.

# Introduction

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- 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

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- 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

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- 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

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## □ *Keep it safe*

- Prevent deterministic effects
- Limit probability of stochastic effects

## □ *Keep it legal*

- Keep it affordable
- Be able to prove it

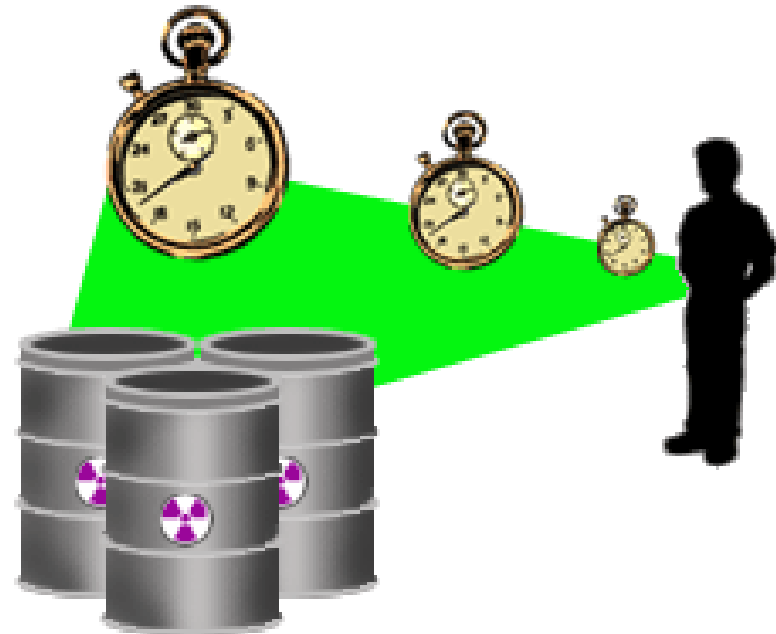
## □ *Help people feel safe*

# #1. Time

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- Minimizing the amount of time in a radiation field reduces the dose.

- Hurry, but don't be hasty.



# Time Reduction Methods

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- 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

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- 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

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- ❑ 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

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- ❑ 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

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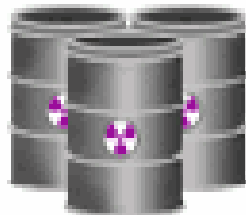
- The distance principle has a purely geometric component.
- *Stay away from it.*
- *Stay upwind.*
- For physically small (point) sources, the dose rate is inversely proportional to the square of the distance away.

# Inverse Square Law

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$$\text{Dose} = \frac{1}{\text{Distance}^2}$$

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 rem

# Inverse Square Law

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$$I_1 d_1^2 = I_2 d_2^2$$

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

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$$I_1 d_1^2 = I_2 d_2^2$$

$$I_2 = \frac{I_1 d_1^2}{d_2^2}$$

$$I_2 = \frac{(100 \frac{mrem}{hr})(1m)^2}{(2m)^2}$$

$$I_2 = 25 \frac{mrem}{hr}$$

# Maximizing Distance Methods

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- ❑ 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

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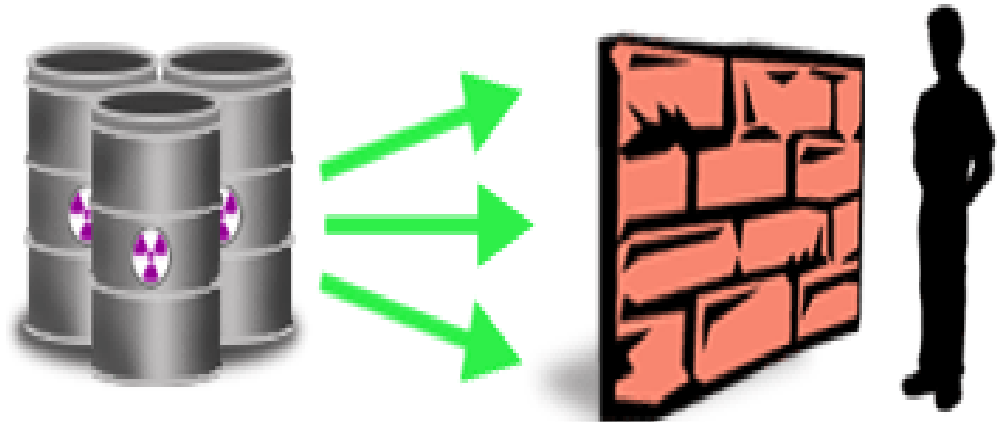


## #3. Source Barrier

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- 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

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

# Neutron Shields

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## □ Fast Neutrons:

- Polyethylene
- Paraffin
- Water
- Other proton rich materials

## □ Slow Neutrons:

- Boron
- Cadmium
- Indium

# Beta Shields

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- Lucite
  - Plastics
  - Low atomic number material
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- Shields are generally not required for alpha-emitting radionuclides.

# Source Barrier Methods

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- *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

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



# #4. Personal Barrier

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## #5. Dispersal

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

## #6. Source Reduction

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- 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

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**Storing waste for decay.**

# #7. Decorporation

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- 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

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- ❑ Washing
- ❑ Debridement (cleaning a wound)
- ❑ Chelating agents
- ❑ Forcing fluids for tritium intakes
- ❑ Blocking tissue uptake (KI for iodine intakes)
- ❑ Surgery

## #8. Effect Mitigation

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- 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

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- 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

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- Using or modifying a radiation technology to produce a lower dose.
- Optimizing an existing technology.
- *Choose the best technology.*



# #10. Limitation of Other Exposures

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- 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.

# Summary of Principles and Commandments

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Principle	Commandment
Time	Hurry, but don't be hasty
Distance	Stay away/upwind
Source Barrier	Keep it in
Personal Barrier	Keep it out
Source Reduction	Use as little as possible
Dispersal	Disperse and dilute
Decorporation	Get it out/off
Effect Mitigation	Limit damage
Optimal Technology	Choose best technology
Limit Other Exposures	Don't compound risks

# References

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- Strom, Daniel J. "Ten Principles and Ten Commandments of Radiation Protection," *Health Physics* 70(3):388-393, 1996.