

Advanced Radiation for Emergency Response

Presented By:

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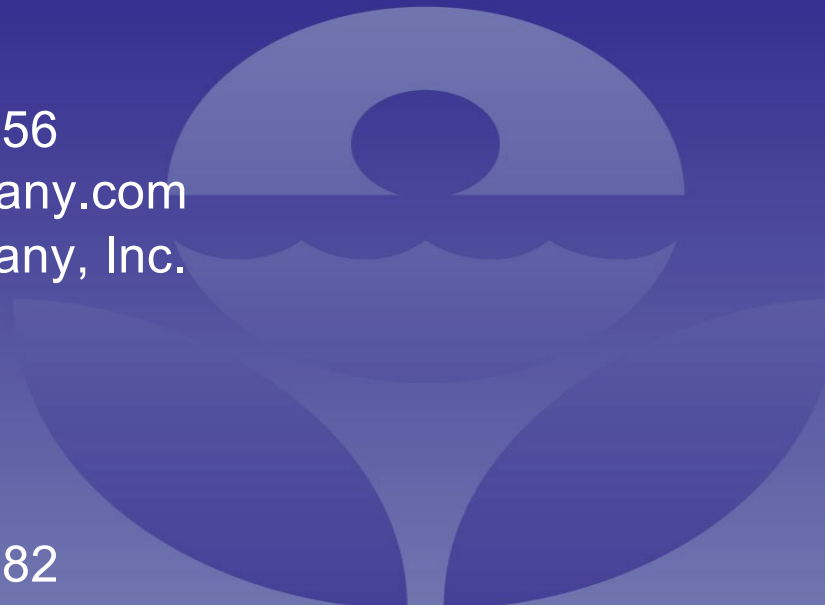
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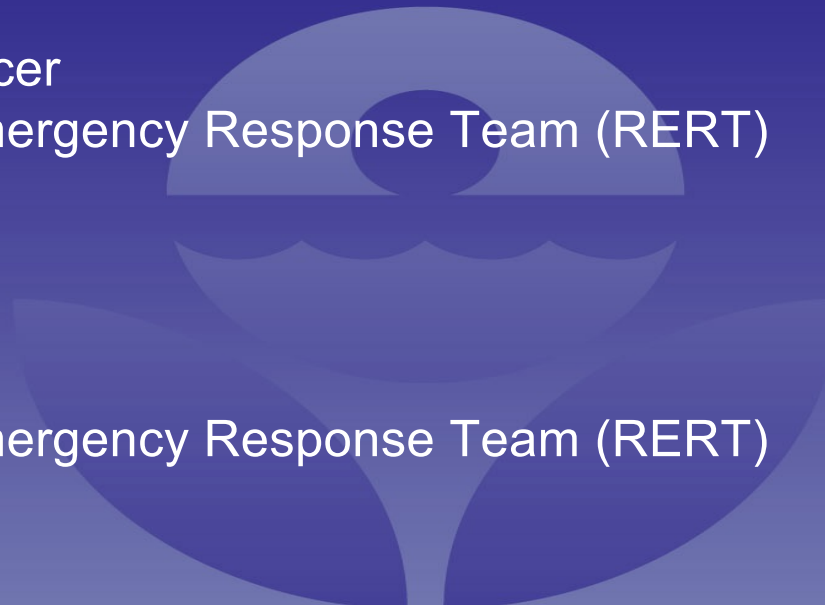
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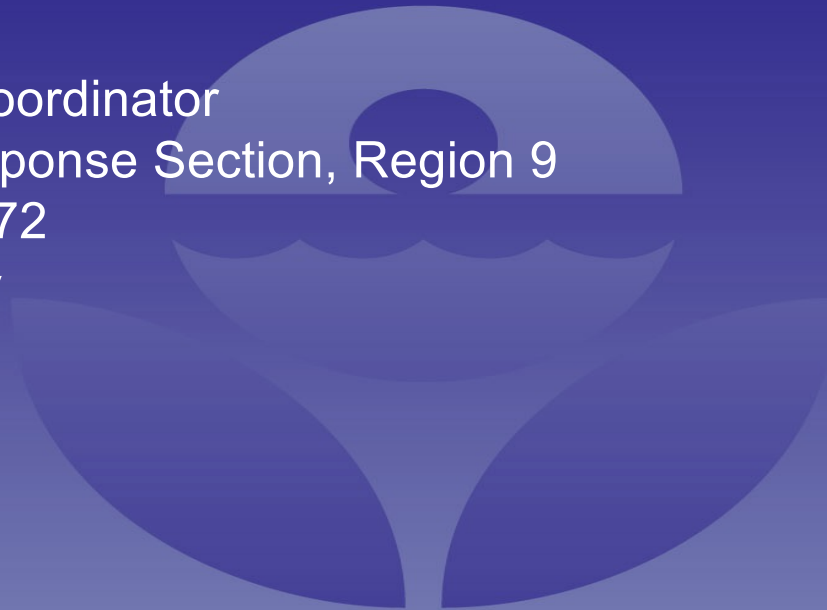
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Introduction

- Name
 - Agency
 - Occupation
 - What radiation training have you taken?
 - Primary interest in taking this class
- 

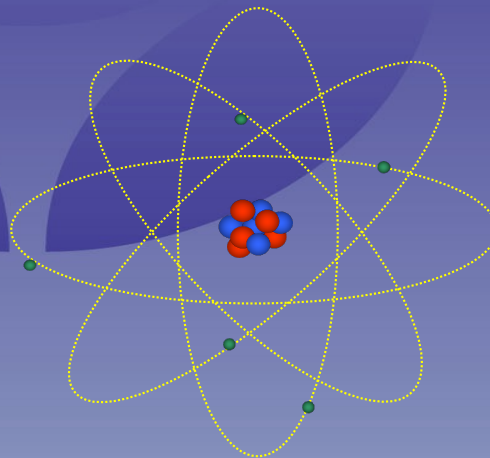
Course Agenda

- Lecture
 - ▶ Quick Review of Radiation Fundamentals
 - ▶ ALARA Techniques
 - ▶ Important Radionuclides of Concern
 - ▶ Response and Control of a Radiological Emergency
- Radiological Incident Case Studies (time permitting)
 - ▶ Look at Me, I Glow in the Dark!
- Hands-on Exercise with Robust Radioactive Sources

Quick Review

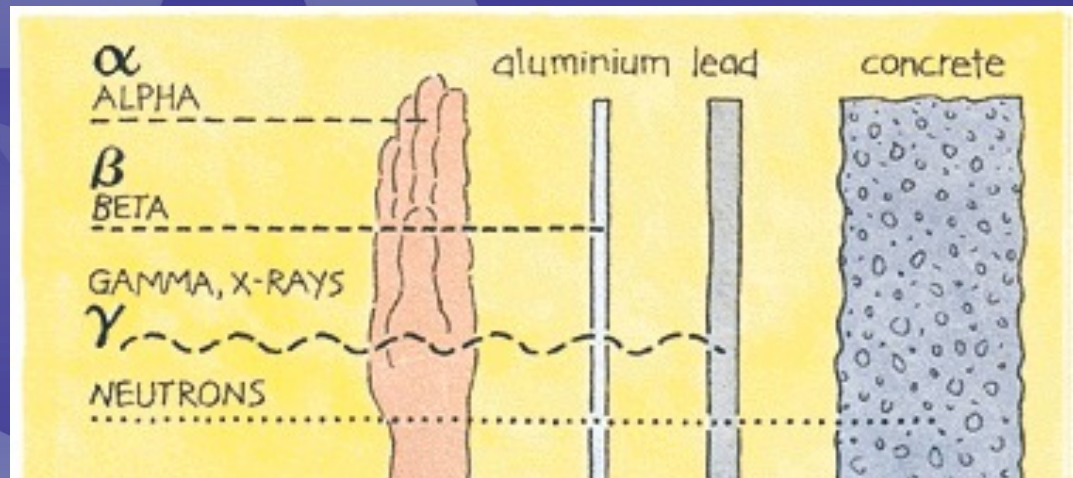


**But I ALREADY
know it all!**



Types of Nuclear Radiation

- Alpha Particles
- Beta Particles
- Gamma Rays
- Neutrons



Measurement and Exposure Summary

- cpm = counts per minute (detected radiation by an instrument)
- Roentgen (R) = exposure (measure of ionization in air)
- Rem or Sievert (Sv) = dose to humans (measure of damage to human tissue)
- Curie (Ci) or Becquerel (Bq) = activity of material (measure of amount of radioactive material)

Counts Per Minute (cpm)

- **Counts per minute (cpm)** is a relative measurement to compare to background or a predefined action level
- cpm \neq activity
- cpm \neq exposure
- cpm \neq dose



Roentgen (R)

- **Roentgen** (ran-'kin) - ionization of air by gamma radiation
- Exposure rate is like a speedometer
- Rate of exposure
 - ▶ microRoentgen per hour ($\mu\text{R/hr}$)
 - ▶ milliRoentgen per hour (mR/hr)
- Roentgen \neq radiation dose to people



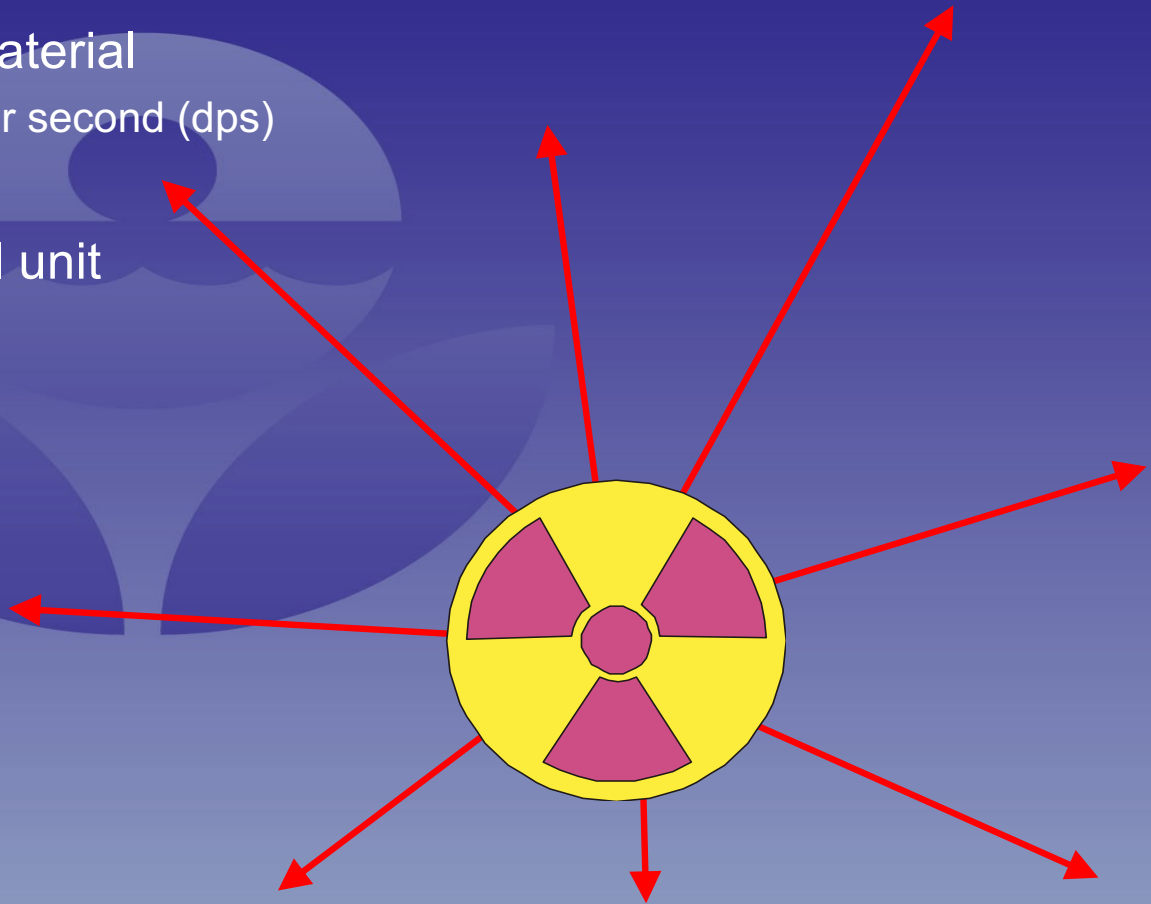
Roentgen Equivalent Man (rem)

- Rem = amount of damage (dose) to human tissue
 - ▶ 1 R \approx 1 rem (gamma or beta only)
 - ▶ 1 R \approx 20 rem (alpha **internal exposure**)
- 1 rem = 0.01 **Sievert (Sv)** - International units
 - ▶ 100 rem = 1 Sv
 - ▶ 100 mrem = 1 mSv
- Rem is like an odometer

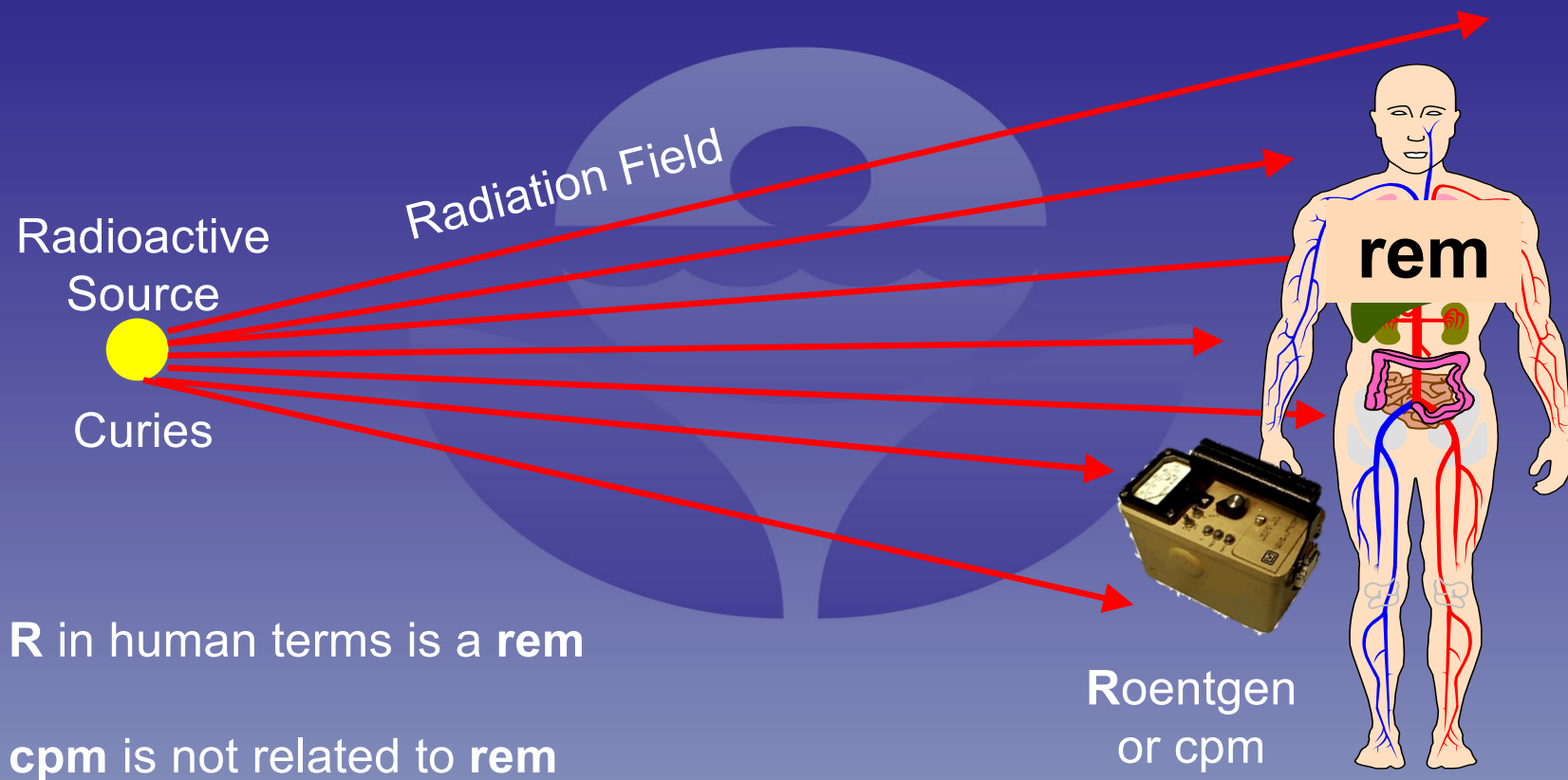


Activity

- **Curies (Ci)** = radioactivity of material
 - ▶ 1 Ci = 37 billion disintegrations per second (dps)
- **Becquerel (Bq)** is international unit
 - ▶ 1 Bq = 1 dps
 - ▶ 1 Ci = 37 billion Bq

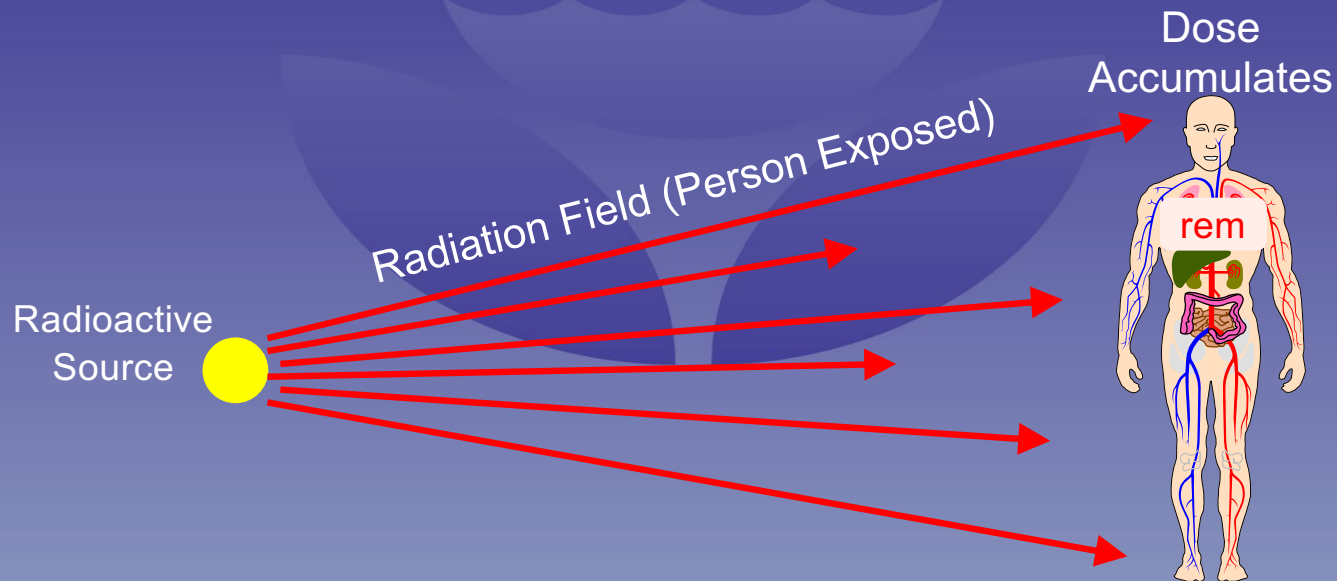


Measurement Illustrated



Exposure and Dose

- Exposure = radiation interacting with your body
- Dose = damage to your tissue from exposure over time



Units Mnemonic

μR = OK



mR = Maybe



R = Rethink



RUN!

Action Levels

- Occupational whole body dose limit = 5 rem/yr
- Emergency worker whole body dose limits (EPA-recommendation)
 - ▶ 5 rem = All activities
 - ▶ 10 rem = Protecting valuable property
 - ▶ 25 rem = Lifesaving or protection of large populations
 - ▶ >25 rem = Lifesaving or protection of large populations on voluntary basis only
- Hot zone = 2 mR/hr (typically)
- Contamination = Twice background (typically)

NCRP Action Levels

- National Council on Radiation Protection & Measurements (NCRP)
- Recommends hot zone limits:
 - ▶ Exposure rate: 10 mR/hr gamma
 - ▶ Surface contamination
 - 60,000 dpm/cm² beta/gamma (~180,000 cpm pancake probe)
 - 6,000 dpm/cm² alpha (~ 18,000 cpm with alpha probe)
 - dpm = disintegrations per minute
- Recommends dose limit: 50 rem
- Recommends dangerous radiation zone: 10 R/hr

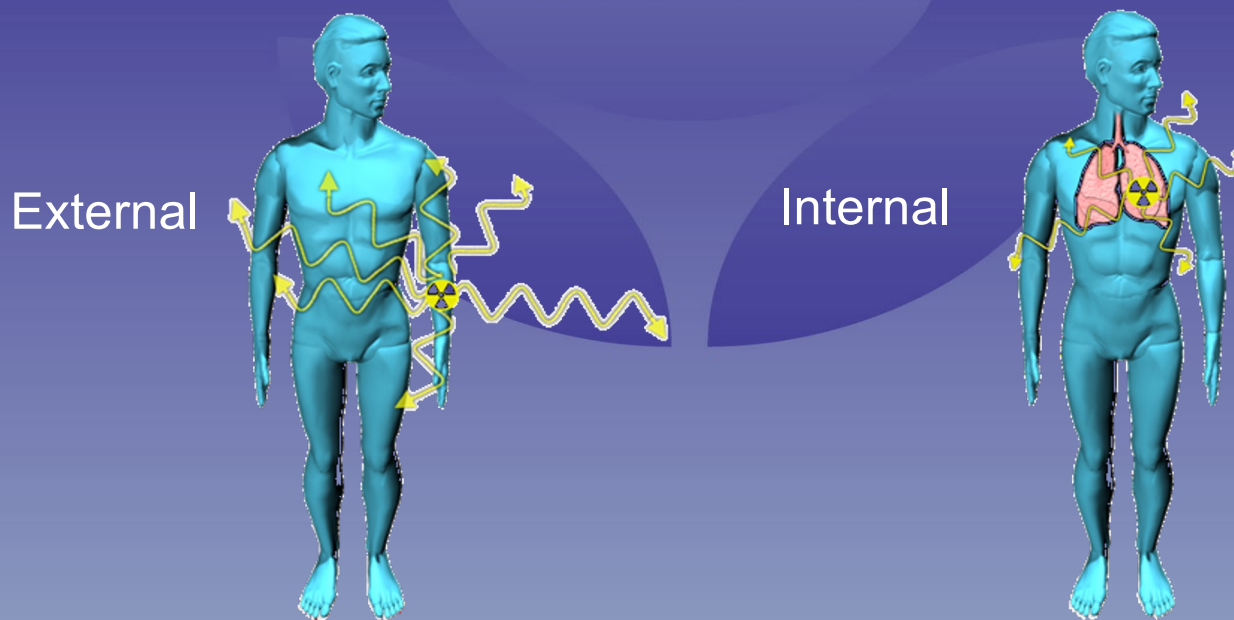
NCRP REPORT No. 165

**RESPONDING TO A
RADIOLOGICAL OR
NUCLEAR TERRORISM
INCIDENT: A GUIDE
FOR DECISION MAKERS**

NCRP
National Council on Radiation Protection & Measurements

Exposure Misconception

- You cannot become radioactive if exposed to radiation!
- You are contaminated if a radioactive material is on (external) or in (internal) your body



Examples of PPE



Instruments

Gamma detector (exposure rate) →



← Real time dosimeter (dose)

Decontamination (cpm) →



← Gamma spectrometer (ID)

Instrument Readings

- Understand the reading on your instruments

- Units

- ▶ $\mu\text{R/hr}$ = microRoentgen per hour

- ▶ mR/hr = milliRoentgen per hour

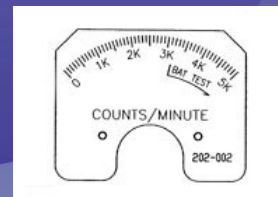
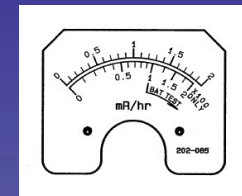
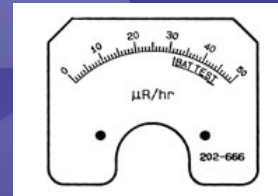
- ▶ μR = microRoentgen

- ▶ mR = milliRoentgen

- ▶ cpm = counts per minute

- ▶ c/m = counts per minute

- ▶ kc/m = kilocounts per minutes or thousand counts per minute (1000 times the reading)



ALARA



Is that a new kind
of perfume?

Dose Management

- As Low As Reasonably Achievable (ALARA)

- ▶ Basis for radiation protection programs
- ▶ Limit dose as much as possible

- Strategies for reducing dose

- ▶ Limit amount of exposure time
- ▶ Increase distance from source
- ▶ Shield sources
- ▶ Rotate entry teams
- ▶ Reduce number of responders on entry team
- ▶ Use dosimeters
- ▶ Start with lower dose limits and increase, if needed

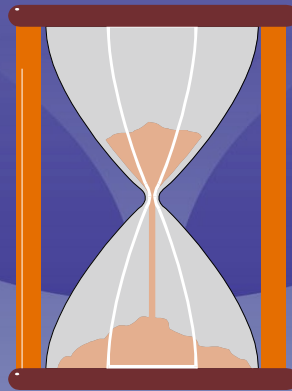


Time

Decrease time



Decrease Exposure



Gamma Radiation Dose Rate (Rate/hour)	Stay Time to Receive This Radiation Dose				
	1 rem	5 rem	10 rem	25 rem	50 rem
1 mR/hour	6 weeks	30 weeks	13 months	2.8 years	5.5 years
5 mR/hour	200 hours	6 weeks	12 weeks	30 weeks	1 year
100 mR/hour	10 hours	50 hours	100 hours	250 hours	3 weeks
1 R/hour	1 hour	5 hours	10 hours	25 hours	50 hours
10 R/hour	6 minutes	30 minutes	1 hour	2.5 hours	5 hours
100 R/hour	36 seconds	3 minutes	6 minutes	15 minutes	30 minutes
200 R/hour	18 seconds	1.5 minutes	3 minutes	7.5 minutes	15 minutes
500 R/hour	7 seconds	36 seconds	72 seconds	3 minutes	6 minutes

Stay-Time

Calculate stay-time:

$$\frac{\text{Dose limit}}{\text{Exposure rate}} = \text{Max exposure time}$$

Example:

$$\frac{1 \text{ rem (1,000 mrem) dose limit}}{200 \text{ mR/hr exposure rate}} = 5 \text{ hours time limit}$$

Stay-Time Example

You measure 2.5 R/hr within 5 feet of an area where you need to perform a complicated rescue operation. How long can you stay in the area before you exceed 5 rem (recommended emergency response limit for all activities)?

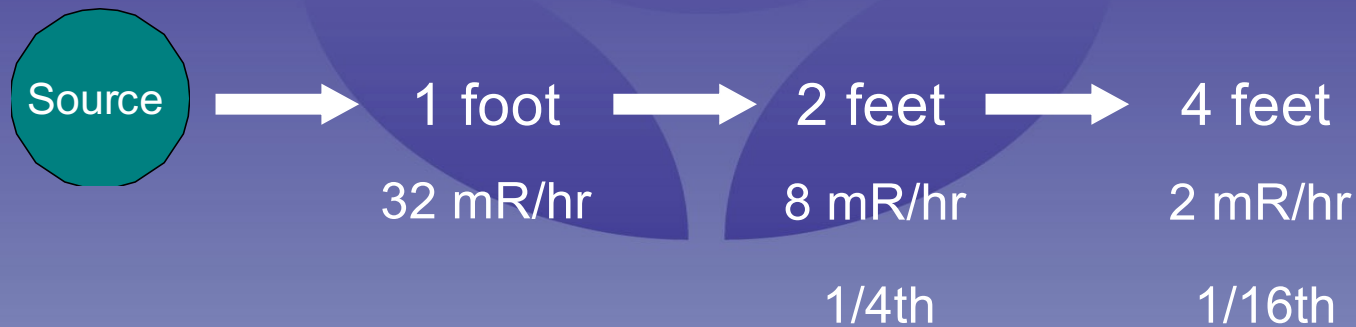
Solution: $5 \text{ rem} \div 2.5 \text{ R/hr} = 2 \text{ hours}$

Stay-time for a 25 rem limit?

Solution: $25 \text{ rem} \div 2.5 \text{ R/hr} = 10 \text{ hours}$

Distance

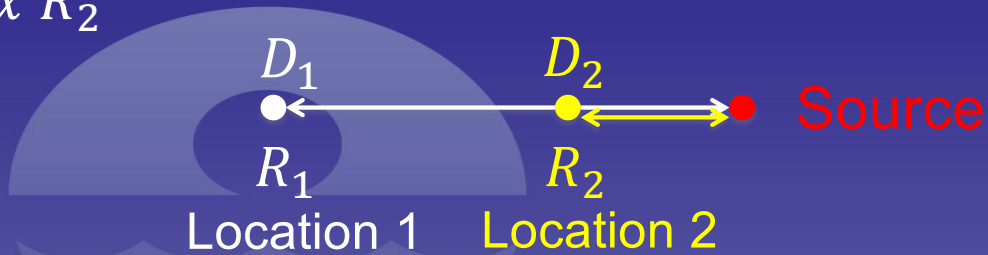
- Increase distance → Decrease exposure
- Double distance → Quarter exposure rate



Inverse Square Law

$$D_1^2 \times R_1 = D_2^2 \times R_2$$

$$\frac{D_1^2}{D_2^2} \times R_1 = R_2$$



D_1 = distance from source at location 1 (where you are now)

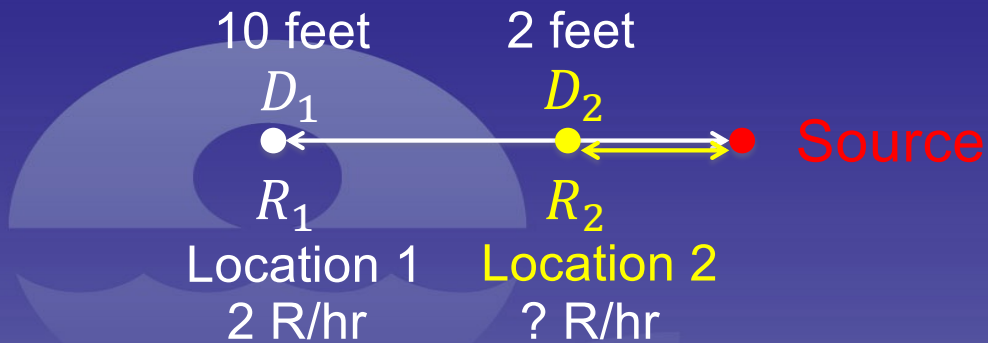
R_1 = exposure rate at location 1

D_2 = distance from source at location 2 (where you want to go)

R_2 = exposure rate at location 2

Inverse Square Law

$$\frac{D_1^2}{D_2^2} \times R_1 = R_2$$



Step 1: $\frac{10^2}{2^2} \times 2 \text{ R/hr} = R_2$

Step 2: $\frac{100}{4} \times 2 \text{ R/hr} = R_2$

Step 3: $25 \times 2 \text{ R/hr} = R_2$

Step 4: $50 \text{ R/hr} = R_2$

Shielding

- Increase shielding → Decrease exposure
 - ▶ Concrete walls, lead shielding, water barriers
 - ▶ Personal Protective Equipment (alpha and beta only)
 - ▶ Drums, plywood, vehicles, natural terrain (hills, trees, rocks) or any dense object



Water Wall

Shielding Factors

Shielding (inches)	Percent Reduction in Exposure		
	Steel	Concrete	Water
0.5	50%	15%	7%
1.0	62%	36%	13%
2.0	85%	46%	25%
5.0	99%	80%	50%

Shielding Example

- A source has an exposure rate of 10 R/hr at 3 feet away. Place 1-inch of steel in front of the source. What is the new exposure rate at 3 feet away?

Shielding factor for 1-inch steel is 0.38

$$10 \text{ R/hr} \times 0.38 = 3.8 \text{ R/hr at 3 feet}$$

Rotate Entry Team

- High exposure rates may result in responders reaching dose limits quickly
- Reduce dose to responders by restricting entry time and using multiple teams to accomplish the mission
- This is called dose sharing; everyone receives some dose, but no individual receives all the dose



Dose Sharing Example

- Scenario:
 - ▶ 100 R/hr
 - ▶ Search and rescue estimates 1 hour for a team of 3 USAR responders
 - ▶ Total projected team dose = 300 rem in 1 hour (for all 3 responders)
 - ▶ Dose limit of 25 rem is reached in 15 minutes
- Solution:
 - ▶ $300 \text{ rem} \div 25 \text{ rem} = 12 \text{ responders}$
 - ▶ Team 1 makes entry for 15 minutes
 - ▶ Team 2 makes entry for 15 minutes
 - ▶ Repeat for Team 3 and Team 4

Reduce Number of Entry Team Members

- Entry team should have minimum responders to accomplish a mission
- Reducing the team size allows for more teams
- More teams making entry can accomplish more tasks
- Technique is combined with dose sharing to reduce dose to all responders

Use Dosimeters

- Zero out dosimeter before entry!
- Dosimeter alert and alarm levels
 - ▶ Set alert to 50% of dose limit or exposure rate
 - ▶ Set alarm to 90% of dose limit or exposure rate
- Look at your dosimeter frequently to assess your dose
- Record your dose after leaving



Start with Low Dose Limits then Increase

- Dose limit is 5 rem
- Start with an incident administrative dose limit of 0.5 rem (500 mrem)
- If responders reach 0.5 rem, increase administrative dose limit to 1 rem
- Increase in additional small increments (0.5 to 1 rem), if necessary

Primary Radionuclides for Terrorism

- Commercially available at high activities:

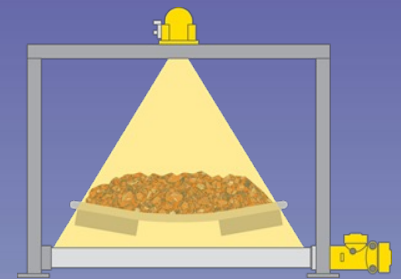
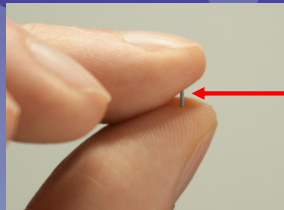
- ▶ Cesium-137 (Cs-137)
- ▶ Cobalt-60 (Co-60)
- ▶ Iridium-192 (Ir-192)
- ▶ Radium-Ra (Ra-226)
- ▶ Uranium-238 (U-238)
- ▶ Strontium-90 (Sr-90)

- Fissile (highly controlled):

- ▶ Uranium-235 (U-235)
- ▶ Plutonium-239 (Pu-239)

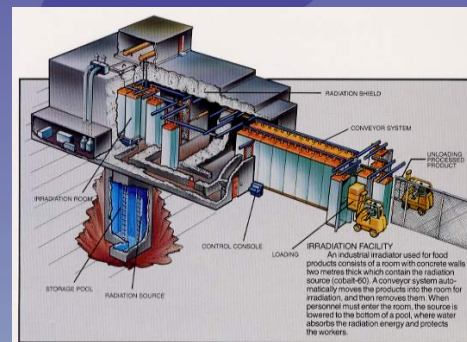
Cesium-137 (Cs-137)

- Radiation: Gamma and beta
- Half-life: 30 years
- Activity: up to 15,000 Ci (66,000 R/hr)
- Environment: Not naturally occurring, but ubiquitous, from atomic bombs and nuclear reactor accidents
- Fate and Transport:
 - ▶ Adheres readily to soil and concrete
 - ▶ Mobile throughout human body, most cleared in few months
- Uses:
 - ▶ Cancer treatment
 - ▶ Nuclear density gauges
 - ▶ Flow meters



Cobalt-60 (Co-60)

- Radiation: Gamma
- Half-life: 5 years
- Activity: up to 80,000 Ci (1,000,000 R/hr)
- Environment : Not naturally occurring, but very small amounts from atomic bombs/nuclear reactor accidents
- Fate and Transport:
 - ▶ Depends on chemical form, but readily adheres to soil
 - ▶ Absorbed by liver, kidney, bones
- Uses:
 - ▶ Radiography
 - ▶ Food / medical irradiators
 - ▶ Cancer treatment



Iridium-192 (Ir-192)

- Radiation: Beta, Gamma
- Half-life: 74 days
- Activity: up to 100s Ci (650 R/hr)
- Environment: Not naturally occurring
- Fate and Transport:
 - ▶ Not likely mobile
 - ▶ Biological half-life is 200 days
- Uses:
 - ▶ Radiotracer in oil industry
 - ▶ Radiography for metal products



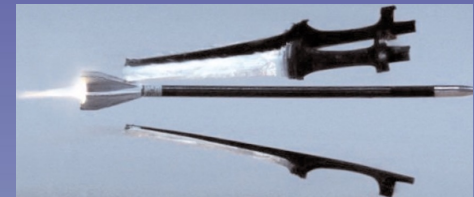
Radium-Ra (Ra-226)

- Radiation: Alpha (beta, gamma)
- Half-life: 1,600 years
- Activity: up to several mCi (1 mR/hr)
- Environment: Naturally occurring
- Fate and Transport:
 - ▶ Adheres well to soil
 - ▶ Deposits in bones, but most quickly cleared from body
- Uses:
 - ▶ Illumination dials, watches, etc.
 - ▶ Brachytherapy



Uranium-238 (U-238)

- Radiation: Alpha (beta, gamma)
- Half-life: 4.6 billion years
- Activity: Variable, dependent on amount
- Environment: Naturally occurring, high concentrations in mine tailings
- Fate and Transport:
 - ▶ Readily adheres to soil
 - ▶ Mostly leaves body within few days
- Uses:
 - ▶ Ceramic glaze
 - ▶ Depleted uranium (DU) for ammunition, counterweights



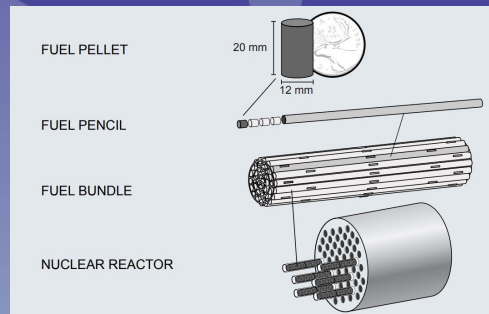
Strontium-90 (Sr-90)

- Radiation: Beta
- Half-life: 29 years
- Activity: up to 465,000,000 Ci (uber high dose rate!)
- Environment: Not naturally occurring, ubiquitous small amounts from nuclear reactor accidents and bomb testing
- Fate and Transport:
 - ▶ Readily adheres to soil
 - ▶ Adheres to bone, cleared from body relatively quickly
- Uses:
 - ▶ Radiothermal Generator (RTG)
 - ▶ Industrial thickness gauges



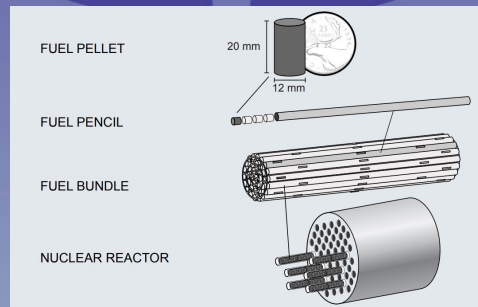
Uranium-235 (U-235)

- Radiation: Alpha (beta, gamma)
- Half-life: 700 million years
- Activity: Little Boy ~ 130 mCi (500 mR/hr)
- Environment: Naturally occurring
- Fate and Transport:
 - ▶ Readily adheres to soil
 - ▶ Mostly leaves body within few days
- Uses:
 - ▶ Nuclear reactor fuel
 - ▶ Nuclear weapons

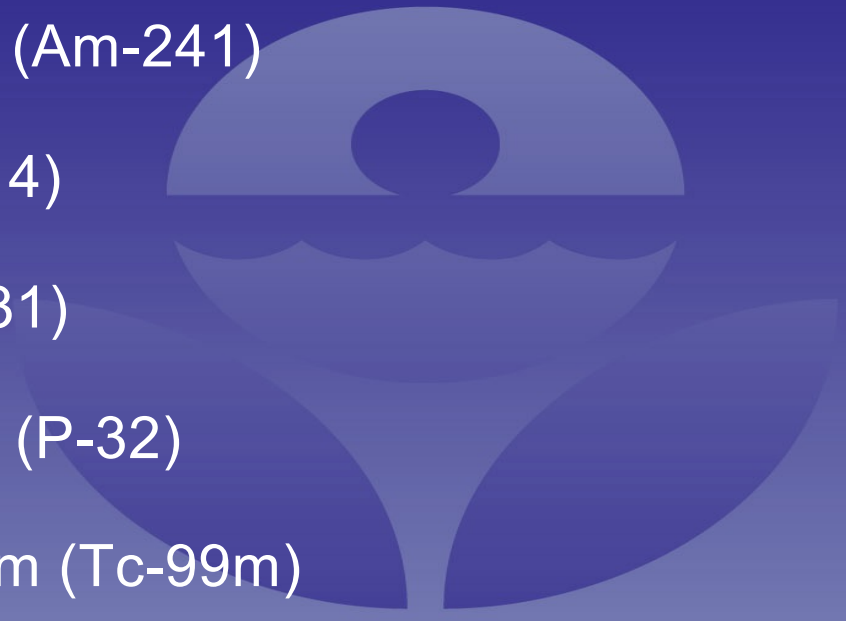


Plutonium-239 (Pu-239)

- Radiation: Alpha (beta, gamma)
- Half-life: 88 years
- Activity: Fat Man ~ 400 Ci (130 R/hr)
- Environment : Not naturally occurring, small amounts from nuclear bomb testing
- Fate and Transport:
 - ▶ Readily adheres to soil
 - ▶ Enters bloodstream into liver and bone for decades
- Uses:
 - ▶ Nuclear reactor fuel
 - ▶ Nuclear weapons



Other Commercial Radionuclides

- Americium-241 (Am-241)
 - Carbon-24 (C-14)
 - Iodine-131 (I-131)
 - Phosphorus-32 (P-32)
 - Technetium-99m (Tc-99m)
 - Tritium (H-3)
- 

Americium-241 (Am-241)

- Radiation: Alpha, Gamma
- Half-life: 433 years
- Activity: 50 mCi (8.5 mR/hr)
- Environment: Not naturally occurring, ubiquitous from nuclear bombs
- Fate and Transport:
 - ▶ Adheres very well to soil
 - ▶ Can stay in body for decades
- Uses:
 - ▶ Smoke detectors
 - ▶ Nuclear density gauge



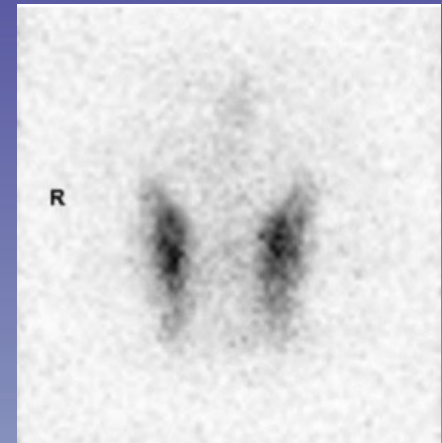
Carbon-14 (C-14)

- Radiation: Beta
- Half-life: 5,700 years
- Activity: Varies by research (~5 Ci)
- Environment: Naturally occurring
- Fate and Transport:
 - ▶ Found in all living organisms
 - ▶ Human body has 0.1 mCi in state of equilibrium
- Uses:
 - ▶ Biological research



Iodine-131 (I-131)

- Radiation: Beta, Gamma
- Half-life: 8 days
- Activity: Varies
- Environment: Not naturally occurring
- Fate and Transport:
 - ▶ Very mobile in soil
 - ▶ Accumulates in thyroid, takes months to clear
- Uses:
 - ▶ Thyroid disorders and cancer treatment



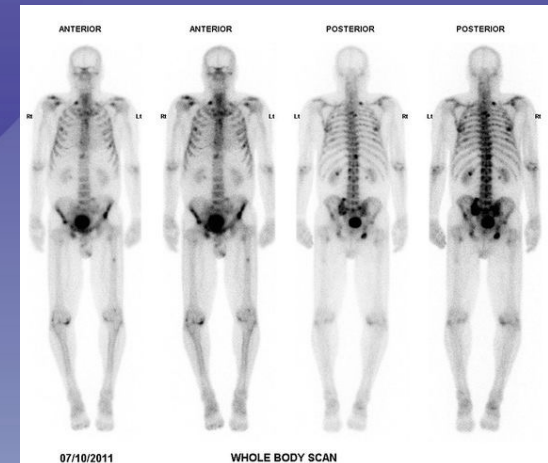
Phosphorus-32 (P-32)

- Radiation: Beta
- Half-life: 14 days
- Activity: uCi to (low) mCi range (very high dose rates!)
- Environment: Not naturally occurring
- Fate and Transport:
 - ▶ Mostly absorbed in soil
 - ▶ Eliminated from body relatively quickly
- Uses:
 - ▶ Biological and genetics research



Technetium-99m (Tc-99m)

- Radiation: Beta, Gamma
- Half-life: 6 hours
- Activity: Varies (very high dose rates!)
- Environment: Not naturally occurring
- Fate and Transport:
 - ▶ Short half prevents long term contamination
 - ▶ Mostly eliminated from body within days
- Uses:
 - ▶ Medical imaging
 - ▶ Nuclear medicine

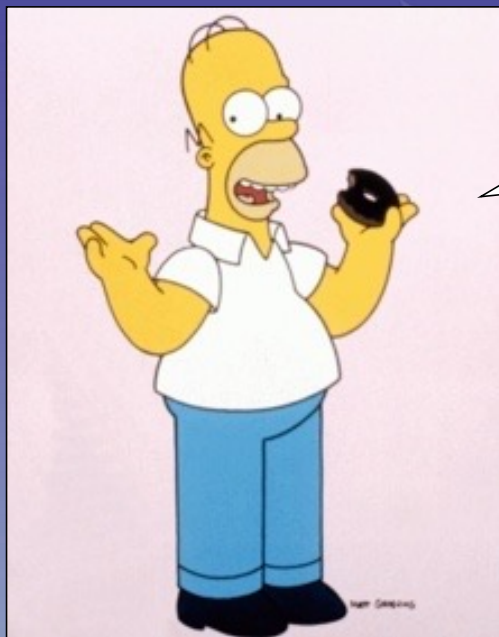


Tritium (H-3)

- Radiation: Beta
- Half-life: 12 years
- Activity: 10,000 Ci (very low exposure rates)
- Environment: Naturally occurring (small amounts)
- Fate and Transport:
 - ▶ Readily incorporates into organic materials
 - ▶ Easily absorbed into human body, months to eliminate
- Uses:
 - ▶ Luminous exit signs, dials, gauges, gun sights, etc.
 - ▶ Biomedical research

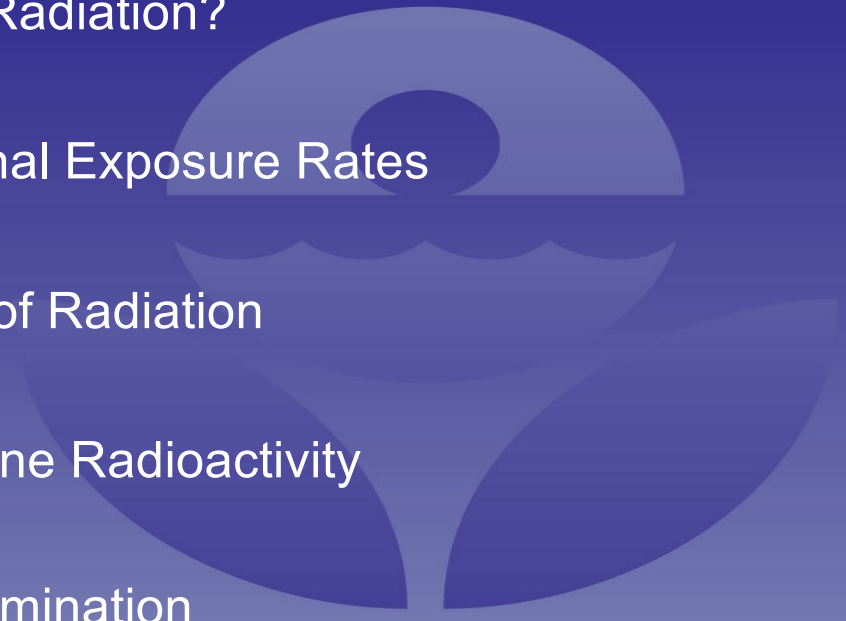


Response and Control of a Radiological Emergency



I know what to do if
\$#!% hits the fan...

Six Primary Response Objectives

1. Radiation or No Radiation?
 2. Determine External Exposure Rates
 3. Determine Type of Radiation
 4. Determine Airborne Radioactivity
 5. Determine Contamination
 6. Identify Gamma Emitters
- 

1. Radiation or No Radiation?

- Verify with sensitive gamma exposure rate instrument
- Before arriving at the scene, turn instrument on and record background (watch/listen for change in rate)
- Twice background or greater = Rad
- Less than twice background \neq Rad



2. Determine External Exposure Rates

- Crucial for health and safety
- Establish Control points
 - ▶ Based on radiation exposure rates ($\mu\text{R/hr}$)
 - ▶ Delineate zones (hot, decon, cold)
 - ▶ DOT ERG: 75 ft min., 330 ft large spill, 1,000 ft fire
- Instruments
 - ▶ Should detect low to high levels of gamma radiation ($\mu\text{R/hr}$ to R/hr)
 - ▶ Most instruments detect only low levels of radiation
 - ▶ Specialized instruments detect higher levels

3. Determine Type of Radiation

- Alpha, beta, gamma
 - ▶ Important for PPE selection
 - ▶ Important for identification of source
 - ▶ Important for determining types of instrument and survey techniques
- Neutrons (depending on the situation)
- This activity can be tricky – seek expert help



4. Determine Airborne Radioactivity

- Helps determine PPE (especially respirator) and extent of contamination
- Air sampling equipment: specialized, 2 or 4-inch diameter filter, flow rate up to 80+ cubic feet per minute
- Placement of air sampler: breathing zone
- Analyze air filters
 - ▶ Field survey meters (like a pancake GM)
 - ▶ Field alpha/beta counter (Ludlum Model 3030)
 - ▶ Send to analytical laboratory
- Plume patterns considerations
 - ▶ Gaseous versus particulate
 - ▶ Big bang versus continuing release
 - ▶ Computer modeling can be helpful



5. Determine Contamination

- Assists in PPE selection
- Assists in positioning support personnel in low or non-contamination area
- Assists in establishing work zones (hot, decon, cold)
- Assists in recovery operations
- Determine removable contamination with swipes



6. Identify Gamma Emitters

- Assists with medical treatment
- Assists with establishing zones
 - ▶ Evacuation
 - ▶ Hot Zone (Exclusion Zone)
 - ▶ Decon Zone (Contamination Reduction Zone)
 - ▶ Cold Zone (Support Zone)
- Assists with determining cleanup strategy



Response Tips

- Approach scene from upwind, just like in a hazmat incident
- Wear a respirator to avoid inhalation of contamination (especially materials that emit alpha)
- Reduce resuspension (ground contamination becoming airborne)
 - ▶ Avoid activities that kick up dust/particulate
 - ▶ Apply fixative agents (foam, water, sealant, etc.)
 - ▶ Cover contamination with plastic sheeting (slip hazard!)

More Response Tips

- Removing outer clothing on a victim will reduce up to 90% of contamination
- Evacuate impacted populations if safe; consider exposure (internal and external) they will receive during evacuation activities
- Shelter-in-place impacted populations if not safe to evacuate but:
 - ▶ Tell them to stay indoors until notified
 - ▶ Close all doors and windows
 - ▶ Keep ventilation on, if needed, but in recirculation mode

EPA's Recommendations on Self-Decon

- Step1:
 - ▶ Place your clothes and shoes in a plastic bag.
 - ▶ Seal the bag.
 - ▶ Keep the bag so it can be evaluated by authorities.
 - ▶ This is vitally important! It will be used to help assess whether you have been contaminated or not.

EPA's Recommendations on Self-Decon

- Step 2:
 - ▶ Shower or wash thoroughly using large amounts of soap and water (take the best shower of your life).
 - ▶ Be careful not to abrade or scratch your skin.
 - ▶ As practical, *gently* blow your nose and *gently* wash out your mouth, ears, and eyes.
 - ▶ Wash any valuables that might have been contaminated in soap and water (jewelry, money, identification cards, etc.).
- Step 3:
 - ▶ Turn on your TV or radio and listen for further instructions.

RDD Action Levels

- Typical action levels may hinder an effective response
- Guidance documents
 - ▶ Conference of Radiation Control Program Directors (CRCPD), *Handbook for Responding to a Radiological Dispersal Device, First Responder's Guide – The First 12 Hours*
 - ▶ National Conference on Radiation Protection and Measurements (NCRP), *Management of Terrorist Events Involving Radioactive Material*, Report No. 138
 - ▶ NCRP, *Key Elements of Preparing Emergency Responders for Nuclear and Radiological Terrorism*, Commentary No. 19
 - ▶ *Los Angeles County Multi-Agency Radiological Response Plan (MARRP)*

LACo MARRP Decision Points

Activities	Exposure Rate (mR/hr)	Cumulative Dose ² (mrem)
All	Up to 10 ¹	Up to 5,000 (5 rem) ^{1, 3}
Critical infrastructure protection	Up to 10,000 (10 R/hr) ¹	Up to 10,000 (10 rem) ¹
Lifesaving or protection of large populations	Up to 200,000 (200 R/hr) ¹ TURN BACK LIMIT	Up to 50,000 (50 rem) ^{1, 4}

LACo MARRP Incident Zones

Incident Zone	Radiation Type	Dose Rate / Contamination Level ¹		Activities ²
Support Zone (SZ)	All	Below Contamination Reduction Zone levels		Staging, Incident Command, etc.
Contamination Reduction Zone (CRZ)	Gamma	<u>1 mR/hr to 10 mR/hr ³</u>		Decontamination Activities ^{6,7}
	Beta	→ 1,000 cpm to 100,000 cpm ⁴		
	Alpha	→ 100 cpm to 10,000 cpm ⁵		
Exclusion Zone (EZ)	Gamma	<u>10 mR/hr to 10 R/hr ³</u>		Evaluation, Mitigation, and Rescue Activities ⁹
	Beta	→ Above 100,000 cpm ⁴	Respiratory protection advised/required ⁸	
	Alpha	→ Above 10,000 cpm ⁵		
Extreme Caution Area	Gamma	<u>Above 10 R/hr ³</u> (200 R/hr Turn Back Limit) ¹⁰	Level B (SCBA) respiratory protection required	Rescue and Preplanned Activities
	Beta	→ No Limits		
	Alpha			

LACo MARRP Contamination Release Limits

Radiation Type	Contamination Level	Maximum Background Levels	Decontamination Instructions
Level 1			
Beta ¹ or	<u>100 cpm to 10,000 cpm</u> or	10 % of Release Level	Decontaminate to 1,000 cpm beta and 100 cpm alpha, if returning to duty station or if doing so does not preclude decontamination of others with higher contamination levels. Provide a copy of <i>Instructions No. 2: Instructions to Public on How to Perform Decontamination at Home</i> before release for self-decontamination.
Gamma ²	(Gamma instruments not usable at these levels)		
Alpha ³	0 cpm to <u>1,000 cpm</u>		
Level 2			
Beta ¹ or	10,000 cpm to <u>100,000 cpm</u> or	10 % of Release Level	If responder is going directly home, decontaminate to Level 2 lower values, then release for home decontaminate in accordance with <i>Instructions No. 2: Instructions to Public on How to Perform Decontamination at Home</i> . If not going directly home decontaminate as noted for Level 1. ^{4,5}
Gamma ²	10 (50) ⁴ µR/hr to <u>100 µR/hr</u> (i.e. 0.01 mR/hr to 0.1 mR/hr)		
Alpha ³	1,000 cpm to <u>10,000 cpm</u>		
Level 3			
Beta ¹ or	<u>Greater than 100,000 cpm</u> or	10 % of Release Level	Decontaminate without delay to achieve Level 2 values. ⁵ If respiratory protection was not used, responder needs to be evaluated to determine if internal contamination bioassay is needed.
Gamma ²	<u>Greater than 100 µR/hr</u> (i.e. Greater than 0.1 mR/hr)		
Alpha ³	Greater than 10,000 cpm		

CDC Radiological Decon for Patients

“Radiation decontamination should not interfere with medical care of patients with life threatening injuries or illness.”

“The right thing to do...[with a contaminated patient with a life threatening condition]...is to admit them to the Emergency department for immediate care.”

Reference: *Interim Guidelines for Hospital Response to Mass Casualties from a Radiological Incident*, Centers for Disease Control and Prevention, Department of Health and Human Services, December 2003

Contaminated Victim Priorities

Management of contaminated, injured patients

1. First aid and resuscitation
2. Medical stabilization
3. Definitive treatment of serious injuries
4. Prevention/minimization of internal contamination
5. Assessment of external contamination and decontamination
6. Treatment of other minor injuries

Contaminated Victim Priorities (cont.)

7. Containment of contamination to the treatment area and prevention of contamination of other personnel
8. Minimization of external radiation to treatment personnel
9. Assessment of internal contamination
10. Treatment of internal contamination (this could be concurrent with many of the above)
11. Assessment of local radiation injuries/radiation burns
12. Careful long-term follow up of patients with significant whole-body irradiation or internal contamination
13. Careful counseling of patient and family members about expected long term effects and risks

Removing Victim from the Hot Zone



Package Victim



Transport into Ambulance



Response Protocols Checklists

- Pre-Incident
- Pre-Entry
- Entry
- Decontamination
- Post-Entry



Pre-Incident Checklist

- ✓ Radiation instruments calibrated yearly (including real-time dosimeters)
- ✓ Sodium iodide scintillation detector (gamma probe) is calibrated for $\mu\text{R/hr}$
- ✓ Geiger-Mueller detector (pancake probe) is calibrated for cpm
- ✓ Alarms have been set for instruments, if applicable
- ✓ Extra batteries and a radioactive check source available for instruments
- ✓ Personnel are properly trained on instrumentation and on basic concepts of nuclear radiation
- ✓ Dosimeters are available for entry team

Incident Checklist – Pre-Entry

- ✓ Turn on instruments before arriving at the incident
- ✓ Set meter to fast, if it has a fast/slow switch
- ✓ Set meter detector selection switch for attached probe, if applicable
- ✓ Set meter switch to ratemeter not scaler, if applicable

Incident Checklist – Pre-Entry

- ✓ Test meters with radioactive check source
- ✓ Record background for each meter before arriving at the incident
- ✓ Don PPE with respirator
- ✓ Assign a real-time dosimeter (zeroed before entry) to each entry person or team (team must stay together)

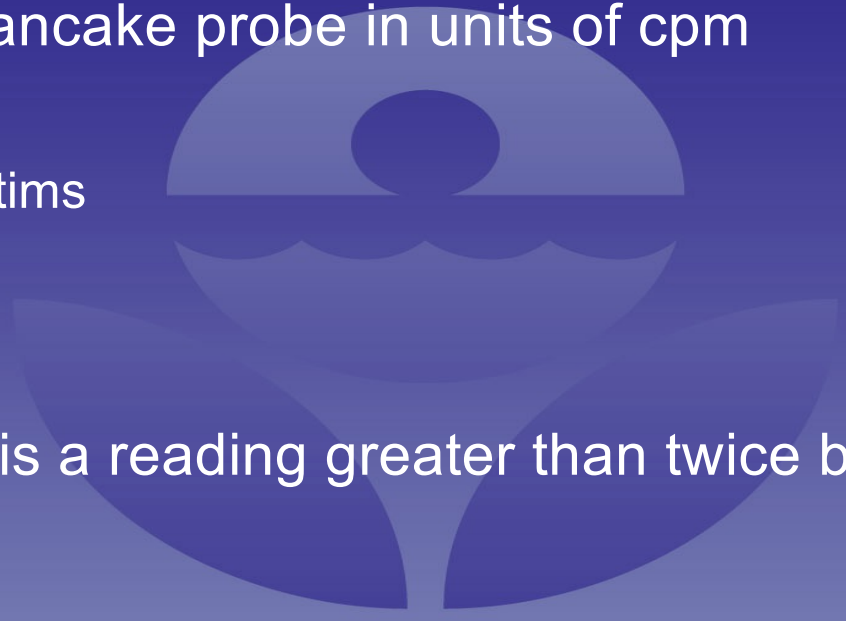
Incident Checklist – Entry

- ✓ Determine if exposure levels exceed action limits, using gamma detector in $\mu\text{R/hr}$ mode
- ✓ Take care of victims first! (contamination second)
- ✓ Conduct survey at a walking rate no faster than 2 feet per second
- ✓ Determine if radiation is present above twice background

Incident Checklist – Entry (cont.)

- ✓ Establish a hot zone action limits (typically 2 mR/hr)
- ✓ Optional procedures
 - ✓ Determine type of radiation after initial survey
 - ✓ Determine if airborne radioactivity is present
 - ✓ Survey for contamination and determine if fixed or loose
 - ✓ Identify radioisotope with field portable gamma spectrometer

Incident Checklist – Decontamination

- ✓ Frisk using a pancake probe in units of cpm
 - ✓ Personnel
 - ✓ Non-critical victims
 - ✓ Equipment
 - ✓ Contamination is a reading greater than twice background
- 

Incident Checklist – Post-Entry

- ✓ Record the exposure from each dosimeter
- ✓ Test meters with radioactive check source (post check to verify that it is still functioning properly)
- ✓ Contain contaminated items for future characterization/disposal
- ✓ Notify appropriate federal, state, and local authorities of incident

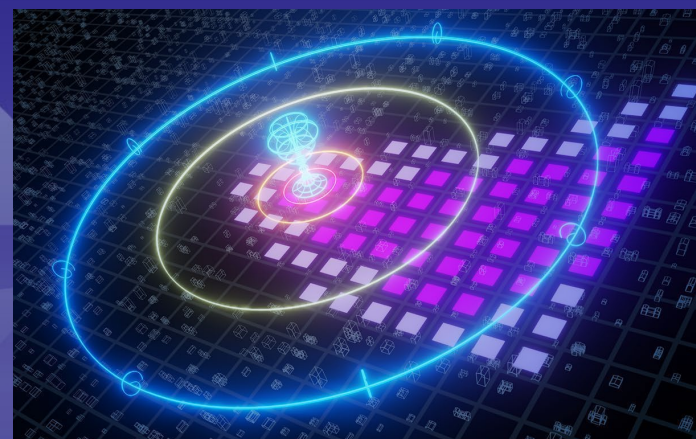
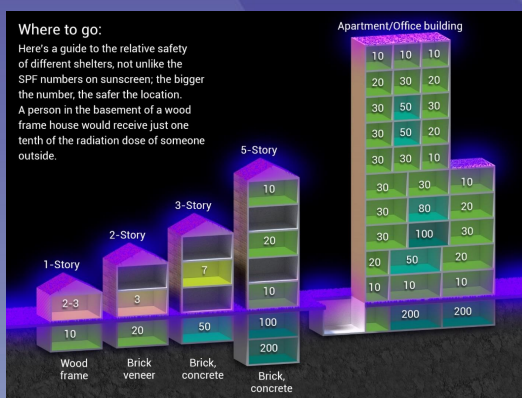
Post-Incident Checklist

- ✓ Medical attention for personnel that exceed an exposure limit
- ✓ Log exposure in medical records
- ✓ Have a cold beer! (antioxidants help reduce free radicals created by radiation exposure*)

* Not an FDA approved treatment for radiation exposure. Consult your doctor before consuming alcohol.

Nuclear Detonation Preparedness and Response

- 5 Missions with 10 Tactics
- Emphasis on shelter-in-place



Nuclear Detonation Response Guidance

Planning for the First 72 Hours

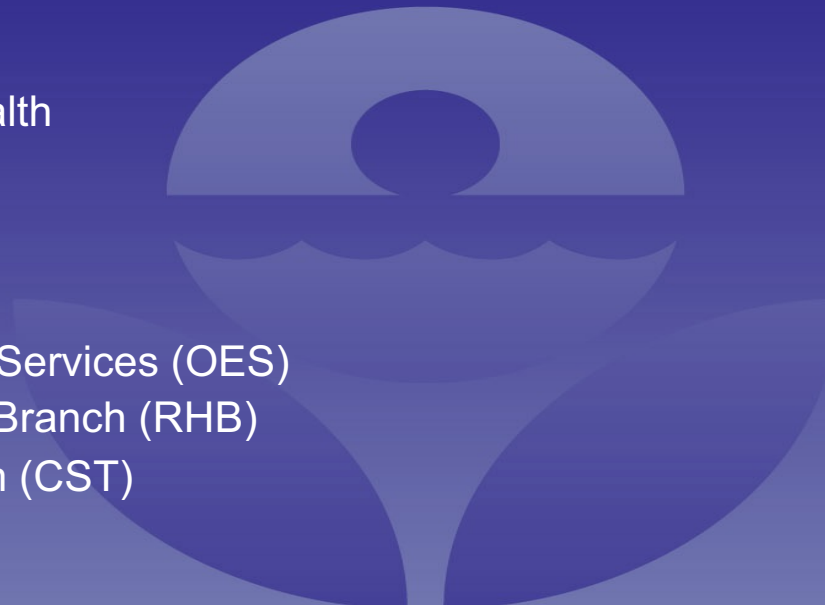
March 2023



FEMA

California Response Assets/Resources

- Internal
 - ▶ Hazmat Team
 - ▶ Environmental Health
 - ▶ Risk Management
- California State
 - ▶ Office Emergency Services (OES)
 - ▶ Radiologic Health Branch (RHB)
 - ▶ Civil Support Team (CST)
- Federal
 - ▶ EPA
 - ▶ DOE
 - ▶ DoD



Who Do You Call?

- California State Office of Emergency Services
 - ▶ (800) 852-7550 (24 hours)
 - ▶ Radiologic Health Branch
- National Response Center
 - ▶ (800) 424-8802 (24 hours)
 - ▶ EPA, DoD, or DOE
- Federal EPA Emergency Response
 - ▶ (800) 300-2193 (24 hours)

Federal Resources

- Federal EPA
 - ▶ Region 9 Emergency Response Section: (800) 300-2193 (24 hours)
 - ▶ Radiological Emergency Response Team (RERT): Las Vegas
 - ▶ National Radiation and Indoor Environments Laboratory (NRIEL): Las Vegas
 - ▶ Emergency Response Team (ERT)-West: Las Vegas
- DOE National Nuclear Security Administration (NNSA)
 - ▶ Radiological Assistance Program (RAP): 8 regional teams (CA): 925-422-8951 (24 hrs)
 - ▶ Aerial Measuring System (AMS): Nevada Test Site (NTS), NV
 - ▶ National Atmospheric Release Advisory Capability (NARAC): LLNL, CA
 - ▶ Accident Response Group (ARG): Albuquerque, NM
 - ▶ Federal Radiological Monitoring and Assessment Center (FRMAC): NTS, NV
 - ▶ Nuclear Emergency Support Team (NEST): Nationwide
 - ▶ Radiation Emergency Assistance Center/Training Site (REAC/TS): Oak Ridge TN

Radiological Emergency Response Exercise



**Exercise!? I'm too
tired.....**


Rules of Exercise

- EPA RERT are the Controllers and Radiation Safety Officers
- “Stop” = Do not move and await instructions
- No touching or moving ANY object
- Radioactive sources are ONLY handled by RERT (it's the law!)

Exercise Scenario

- FedEx truck accident
- Packages spilled onto highway, many damaged
- You arrive on scene as the first responders
- FedEx driver is seriously injured and sent to a hospital; however, before she departs, she mumbles that there is hazmat

Exercise Mission

- Locate radioactive materials
 - Delineate response zones
 - Determine if radioactive materials have been released from their container
 - Be safe!
- 

Exercise Location

