	OFFICE OF STATE FIRE MARSHAL *REGIONAL HAZARDOUS MATERIAL EMERGENCY RESPONSE TEAMS* **STANDARD OPERATING GUIDELINES**	**Number: T-026** **Adoption Date:** July 12, 2011 **Review/Revision Date:**

OSFM Approved: Mark Wallace Date 7/12/11 Mark Wallace, State Fire Marshal	Mariana Ruiz-Temple Date Mariana Ruiz-Temple, Emergency Response Mgr

SUBJECT: Response to Radiation Incidents

OBJECTIVE: Outlines safe and effective response protocols to radiation incidents, whether accidental or intentional

I. Scope

Provide guidance on how Regional Hazardous Materials Emergency Response Team personnel safely mitigate incidents where sources of radiation are found or are part of a hazardous materials release. This procedure does not specifically apply to Improvised Nuclear Devices or other nuclear detonation events.

II. General

Since ionizing radiation cannot be detected by normal senses, detection equipment must be used if radiation is suspected, or to handle events with radiological sources and/or contamination present. Monitors should be employed at incidents with explosions, facilities with radiation processes or devices present, product with rad placards or sampling of unidentified powders.

III. Equipment / Resources

Equipment shall be bump tested with a state provided exempt button source, before each use. In addition, have the detectors and pager type dosimeters calibrated by an approved facility either annually or bi-annually, depending upon your agreement with state radiation officials. The Canberra EPD's should be calibrated with the state provided FC2B pig type source on an annual basis. Also perform the unit operational verification tests on the Canberras each quarter. check and replace batteries on all units when needed.

1. Ludlum survey (2) and exposure meters (2)

2. Dositec Electronic pager type dosimeters

3. Canberra Mini-Radiac Electronic Personal Dosimeters (EPD) (6)

4. Minimum of 2 (exempt button type - 1 *u*ci to 5*u*ci activity check sources – One Strontium 90 Beta only source and one Cesium 137 Gamma and Beta source)

IV. Scene Considerations

Ensure all personnel on scene have appropriate respiratory protection, survey monitors if available (put on – between waist and neck, turn on and ZERO OUT DOSE) and have them don electronic dosimetry, if:

a) a rad placard is evident
b) response is to a facility with a known radiation sources
c) unidentified explosions, or
d) known or suspected CBRNE/WMD scenes.

Initial companies may designate the Warm Zone boundary if they have monitoring equipment (10 mR/hr). HMRT technicians will monitor and determine the Hot Zone Boundary (10+ R/hr). Consider an initial general fire plume plot or for significant incidents, contact IMAAC for a radiation plume projection model.

Basic Priorities

- Make notifications
- Request technical support
- Establish hazard zones
- Establish PPE levels
- Rescue victims and establish decon operations
- Review Protective Action Recommendations

1. Incidents with Fire and/or patient rescue considerations:

a. Consult the ERG for appropriate downwind evacuation zones
b. Minimize the use of water and control runoff if possible
c. Minimum PPE is full turnouts with SCBA
d. Remove patients quickly, medical triage before radiation concerns
e. Alert hospitals to prepare for contaminated patients.

2. Public Protection

a. Protection in place initially, close doors, window, turn off ventilation
b. Utilize PEAK for more detailed nuclide information if known
c. Consult PAG's regarding initial recommendations for downwind populations
d. Protect in place initially
e. At remote medical care points, triage for medical first (injury trumps rad issues) and then scan for contamination. Contamination decision point is

any reading of ≥ 2 times background – screen 1" away, 1"/second, head, hands and feet (approx 2 min per patient).

3. **Transportation Incidents:**

   a. Identify *all* hazards in addition to those indicated by the rad placards/docs
   b. Limit ***time*** of exposure, maintain ***distance*** from radiation sources and use vehicles or buildings as ***Shielding***
   c. Quickly remove patient from the hazard zone and treat medical concerns before radiological ones.
   d. Notify OERS, indicating a rad incident and ask them to notify state resources, including Radiation Protective Services, FBI, EOD and CST if necessary.
   e. Consult the ERG, stopping fires or runoff if possible, staying upwind
   f. Restrict access to **at least 75 feet** from a small spill or leak.

4. **Unknown Powder/Chemical:**

   a. Take an all hazards approach to any unknown product.
   b. Begin the 10 Step process with radiation screening with a contamination meter. Monitor ½" to 1" away and 1" per second. Determine if ionizing rad is present in the sample. Try to categorize as Alpha, Beta or Gamma, with shielding and/or Alpha probe.
   c. If positive, make notifications and obtain resources to analyze and identify the particular nuclide with an isotope identifinder device (RIID).
   d. If supporting sampling operations, swipes should be 100 cm/sq (size of a dollar bill). Remove sample to decon line to check for elevated readings. Coordinate and analyze with RPS and CST specialist personnel.

5. **CBRNE/WMD incidents or unknown explosions**:

   a. Have responders turn on their rad monitors if available. Set units to 100x scale and approach scene.
   b. Monitor the ground upon arrival and compare reading with normal background levels.
   c. Approach scene and determine exposure rates, setting the **WARM ZONE** hazard perimeter at **10 mR/hr.**
   d. Obtain as much scene information as possible, including plume description, device size or explosion type, material form, patient numbers.
   e. Have resource enter this information into plume modeling system
   f. **Be aware of the potential for secondary explosive devices. Do not operate electronic equipment in the warm zone or closer than 100 feet from source.**

6. **Decontamination of contaminated patients and Fire/HMRT personnel:**

   a. Personnel may be contaminated with alpha or beta particulate radiation and must be decontaminated before leaving the warm zone

b. Anyone that was in the warm or hot zones must be surveyed with radiation detection instruments before being released into the cold zone.
c. Contaminated patients must pass through the decon corridor or kept in a holding area for decon and triage.
d. Hold and bag all contaminated clothing and equipment in the decon area.
e. All treatment personnel should use the following PPE as a minimum: N95 mask, APR, PAPR or SCBA, clothing that has maximum coverage and other universal precautions
f. Masks may be given to patients to limit further inhalation of rad particles
g. Most contamination can be removed from exposed skin areas with moist wipes, swabs or adhesive tape. Survey and mark remaining hot spots with a marking pen.
h. Wounds can be irrigated with lukewarm water, but DO NOT scrub, or abrade

V. Attachments

1. Radiation Response Checklist

2. Radiation Protection Zones

3. Radiation Safety Officer

4. Plume Modeling Procedures (IMAAC)

5. IED Standoff Distances

6. Protective Action Guidelines (PAGS)

7. Patient Screening Procedures

8. Ludlum Field Guide

9. Canberra Field Guide

10. Dosimeter Tracking Form

11. Radioisotopes

12. Nuclear Terms

13. Radiation Response Resources

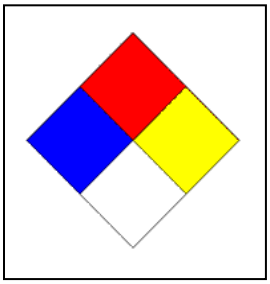
Location:

RADIOLOGICAL INCIDENT
Response and Assessment Checklist

Date: Time:

☐ **PRE-ARRIVAL: Activate radiation plan en route**

☐ Bump test equipment ☐ Obtain initial rad readings via radio ☐ Notify OERS



☐ **Oversee/Assist first responders with rescue & pt treatment/decon**

- Grab/Strip/Wrap/Ship — Turn on/Put on Radiac EPD's
- Injury trumps rad contam — Eval PPE for Warm Zone/resp protection
- Patient symptoms — Eval red pts for Gamma contam/mark w/**G** for hosp
- Pt screening, 1" away, 1"/sec, Heads/Hands/Feet – 2 min/pt - > than 2X background = contam

☐ **Initial Scene Assessment Information**

Incident Type: ☐ Open container ☐ Spill ☐ Explosion ☐ Fire ☐ Unknown / Other

Placard _____ Special Hazards _____

Form: Solid ☐ Liquid ☐ Gas ☐ Powder ☐

Release Amt _____ RP name _____ Transportation Mode_____

Initial Rad Readings _____ Location _____ ☐ Assess for IED's

☐ **Make Agency Notifications** - (Refer to opposite side of this form)

☐ **Evaluate/Establish/Verify radiation protection boundaries**

- **10mR/hr** Warm Zone and Decon Corridor
- **2mR/hr** Public Exclusion Zone – safe CP location
- **10R/hr** Hot Zone

***ALARA* "as low as reasonably achievable**
Time, Distance, Shielding

☐ **Assess radiation hazard** - ☐ Rad RSO or Specialist _____

Alpha ____ Beta ____ Gamma ____ Neutron ____ Accidental ____ Intentional ____ Form_____

☐ Obtain background _____ Instrument type _____ Probe type _____

Readings/Alarms: Exposure Rate _____ Count rate _____

☐ Other Info: Shielding material: Lead ☐ Plastic/Paraffin ☐ Metal ☐ Other ☐

☐ Special containers: Cylinders _____ Totes: _____ Boxes _____ Package Type _____

☐ **Assess and Identify Specific Nuclide(s)**

☐ RIID Device – Acquire Spectrum – Min sample collection time 300 seconds ☐ Neutron test

☐ Communicate Nuclide ID and rad emission type to hospital ☐ Submit to DOE reachback

Emerg Resp Officer 202-586-8100 email triage.data@hq.doe.gov

☐ **Follow-up Communications :**

RESOURCES

- **OERS** (800-452-0311)
- Oregon Radiation Protective Services (**RPS**) (971-673-0490 or 503-799-6977)
- **HMRT** (2nd unit if needed) thru OERS
- **ODOT** (Transportation only) (503-986-3020)
- **FBI** (503-224-4181)
- 102nd Civil Support Tm **(CST)** (503-584-3112 or 932-6813)
- **RAP Team** (509-373-3800
- **EOD** _____

- **NARAC/IMAAC** (925-424-6465) **DOE** (509-373-5325) **RAP TEAM** (509-373-4348 or 5325)
- **CHEMTREC** (800-262-8200) Info they will need: Your title, Callback #, Dispatch #, Incident description, injuries/exposures, material/container type, release amount, location, weather

NOTES

RAD PROTECTION ZONES

Public Security perimeter

WIND

HOT ZONE

10R+high rad zone

WARM ZONE

10mR-10R, medium rad zone

1O mR
Inner perimeter control line

Decon

2 mR
Outer perimeter control line

Patient Flow

2mR-10mR Civilian exclusion zone

Decontamination Corridor

TRIAGE

Command

COLD ZONE

Background < 100 cpm = clean zone

10 mR/hr Warm zone perimeter

10 R Property saving guideline limit

25 R Dose limit for life saving rescue

200 R/hr Absolute turn back level

1Ur = 0.001mR = 0.000001R = 0.01uSv = 0.00001mSv

1 Sv = 100 Rem, 1 Gray = 100 Rad

On arrival, approach on 100X scale

Canberra – Dose Alarm at 20 R max

TURN ON – PUT ON – CLEAR DOSE

Monitor 1" away and 1" per second

RADIATION SAFETY OFFICER

- ☐ **Check in with IC – Report to Hazmat Branch**
- ☐ **Integrate with Rad officials upon arrival - EDU – RPS – FBI – CST – RAP – FRMAC**
- ☐ **Assess Radiation Levels – Alpha, Beta, Gamma, Neutron**
- ☐ **Verify Radiation Boundaries**
- ☐ **Verify / Redefine Contaminated Areas**
- ☐ **Establish Dose Guidelines and Dosimetry**
- ☐ **Identify Radioisotopes**
- ☐ **Review Monitoring and Decon Operations**
- ☐ **Support Medical Branch – Insure Rad info is communicated to Hospitals**
- ☐ **Support / Review Plume Modeling Info and Public Action Recommendations**
- ☐ **Provide support to the PIO**
- ☐ **Support / Review documentation of doses**

PLUME MODELING PROCEDURES

NARAC (National Atmospheric Release Advisory Center)
IMAAC (Interagency Modeling and Atmospheric Assessment Center)

EMERGENCY CONTACT NUMBERS – 24/7

NARAC: 925-422-9100 IMAAC: 925-424-6465 FAX: 925-423-4527

EMAIL narac@llnl.gov or imaac@llnl.gov WEB imaacweb.llnl.gov

1. **Collect as much incident information as possible:**

Incident/Facility Name _____

WHEN Date _____ Release Start Time _____ Release End Time _____

WHERE Address _____ City, State _____

Latitude / Longitude (optional) _____

WHAT Complete as much as is known:

- **Incident Type** (spill, fire, expl, or unk) _____
- **Material Type** (rad, chem., bio, or unk) _____
- **Specific Material** (e.g., Cl, Cs-137, Anthrax, etc.) _____
- **Specific Form** (e.g., gas, liquid, powder, etc.) _____
- **Amount Released or at Risk** (rail car, 10 lb, 100 Ci, etc.) _____
- **Plume Height** (above ground) _____
- **Local Weather Conditions (optional)** wind speed _____ direction _____
- **Distribution –** where (EOC, JOC, IC) & how

2. **Transmit incident info to IMAAC via one of the numbers shown above**

3. **Provide contact information: Name _____ Title _____**

Organization _____ Call-back number _____

E-mail _____

IED SAFE STANDOFF DISTANCES

Threat	Explosive	O/S Evac	Build Evac	Lethal Blast
PIPE BOMB	5 lbs	850 ft	70 ft	
SUICIDE VEST	20 lbs	1360 ft	110 ft	
BRIEFCASE	50 lbs	1850 ft	150 ft	
SEDAN	1000 lbs	**1750 ft**	**400 ft**	**125 ft**
SMALL VAN	4000 lbs	2750 ft	640 ft	200 ft
DELIV TRUCK	10,000 lbs	**3750 ft**	**850 ft**	**300 ft**
SEMI-TRAILER	60,000 lbs	7000 ft	1570 ft	600 ft

Threat Descrip	LPG Size	Fireball Size	Safe Distance
SM LPG TANK	20lbs/5gal	40 ft	160 ft
LG LPG TANK	100lbs/25gal	70 ft	280 ft
SM LPG TRUCK	8,000lbs/2,000gal	290 ft	1170 ft
LG LPG TRUCK	40,000lbs/10,000gal	500 ft	2000 ft

GUIDELINES FOR RADIATION EXPOSURE LIMITS

Category	Description	Reading (mREM)

Levels are given in Total Effective Dose Equivalents (TEDE) unless otherwise noted
1 uR = 0.001 mR = 0.000001R = 0.01 uSv = 0.00001mSv 1 Sv = 100 REM

RESPONDERS			
Contamination outer perimeter	2 mR/hr		
Warm Zone	Industrial release	2 mR/hr- 10R/hr	
Hot Zone	RDD	10 mR/hr- 10R/hr	
Lifesaving (informed consent only)	10 R +	25,000 mR	250 mSv
Protecting major property	Protection of large populations	10,000 mR	100 mSv
Turn Back – regardless of life saving issues		**200 R/hr**	
GENERAL PUBLIC			
Emergency limits	Seven consecutive days One hour limit	100 mR 2 mR	1mSv 0.02mSv
Emergency Protective Action Guides (CEDE)	Max to thyroid Max to whole body Relocate if 1st year dose >	15,000 mR 5,000 mR 2,000 mR	150 mSv 50 mSv 20 mSv
Public Sheltering decision For Early Phase	Shelter if projected dose No shelter if projected dose	> 1 Rem < 100 mR	
Public Evacuation decision For Early Phase	No evac if projected dose No evac for special populations if projected dose	< 5 Rem < 10 Rem	
Decon and dose reduction for intermediate phase	Yes, if annual projected dose	> 500 mR	

Business closures Decon of people Unconditional release Contaminated Medical rad evaluation Decon of equip & animals Release Impound / refer Contaminated	If annual projected dose for the first year < than 2x background > than 2x background > than 2x background after decon	> 2 Rem
OCCUPATIONAL		

NOTES:

Normal background	**0.01 – 0.02 mR/hr**
Annual background	**approx 250 mR/hr**

Canberra Dosimeter Settings

Rate	**Upper Limit**	**Lower Limit**
	10 R/hr	**2mR/hr**

Dose	**Upper Limit**	**Lower Limit**
	20R	**5R**

RADIATION SCREENING PROCEDURES

1. Proceed to screening point and await arrival of civilians and health department staff. Prepare to receive several hundred or more at each site

2. Minimum resources needed at each screening point:

    - 2 + fire responder companies (each FF can monitor approx 25 pts per hour)
    - 1-2 police patrol units
    - Equipment:

        - Clipboard with screening documentation forms
        - Traffic cones with tape to designate waiting lines
        - Megaphone to give group directions when needed
        - At least 5 radiation contamination monitors
        - Canberra dosimeters for each first responder
        - SIRAD rad detection badges for health dept staff, if available
        - Self decon kits with instructional handouts
        - Several boxes of Tyvek suits

3. Screening Procedures:

    - Form multiple lines, depending on # of civilians
    - One FF with contam monitor for each line – set unit to 1 scale – turn down the volume and watch scale.
    - Hold monitor 1" away from body and monitor in this order (approx two minutes per person) 1 inch per second
    - **Head** (face, hair and head in that order)
    - **Hands** (fronts then backs)
    - **Feet** (bottoms then tops)

4. An individual shall be considered **CONTAMINATED** and in need of decon, when readings are found that are over **100 CPM** (2x background level)

    Send these patients to holding area and should be directed to remove outer clothing. Do spot decontamination on scene, don Tyvek suits and be re-monitored.

    Patients that have less than **50 CPM** (approximate background radiation levels) are not considered as contaminated

5. Bag and tag all clothing of patients from the holding area

Ludlum 2401-EC2A ***Exposure Rate*** Meter **Gamma, 0 - 2000mR/hr**
Ludlum 2401-P ***Survey*** Meter **Alpha/Beta/Gamma, 0-15mR/hr, 0-50,000 cpm**

INSTRUCTIONS

1 Test the instrument
   a. Turn Mode Selector to [BAT CHECK]
      i. The needle should move to the "BAT OK" range
      ii. If the needle is below (to the left) of "BAT OK", replace the battery (9-volt)
   b. Check for Radiation Response
      i. Turn Mode Selector to either [QUIET] or [NORMAL]
      ii. Place meter on a radiation "check source"
      iii. The needle should move, indicating radiation is present
      iv. The QC program may require you to record the reading
2 Turn Mode Selector to either [QUIET] or [NORMAL]
3 Set Range Selector Switch to X1
4 If Radiation Field is near the end of the scale (far right side) move up to the next scale
5 If the Needle "Pegs", and will not change:
   a. Cycle Power: Turn Mode to "OFF", and listen for a high-pitched chirp
   b. Move Range Selector Switch up to a higher setting
   c. Turn Mode to either [QUIET] or [NORMAL]
   d. Repeat if needed, up to the highest setting

2401-EC2A

2401-P

Display Scale

Use the mR/hr Scale for EC meters (Energy Compensated)
-Pancake meters use the cpm scale (e.g. Ludlum 2401-P)
-Ignore the Extra Scales (e.g. CPM scale)
-Read the point where the needle crosses the mR/hr scale
this picture shows the needle at ~0.92
-The needle will constantly move. Use the center-point.
e.g. if the needle moves between:
0.9 and 1.1, the value is ~1.0

BAT OK Scale (lower right corner of display)
Used during BAT CHECK test (on Mode Selector)
-Needle should be in the BAT OK zone during the test

Mode Selector

Set to either Quiet, or Normal during operation

Quiet	Measures Radiation without speaker
Normal	Measures Radiation Speaker "clicks" with radiation counts
Bat Check	Tests Battery
OFF	Turns instrument off

Range Selector Switch

Multiply the Range by the Displayed Number
-In this example:
Display reads ~ 0.92
Range Selection is X10
(0.92 x 10 = 9.2)
Exposure Rate is ~9.2 mR/hr

Canberra UltraRadiac
Personal Radiation Monitor

START UP INSTRUCTIONS

1. Press and hold [ON/OFF]
   -Listen for a click, and display will turn on

2. Clear Dose: Press and Hold [DOSE+CLR/TEST]
   -Hold buttons until Flashing Stops
   -Display changes to "00.0 uR"
   -Wait for Display to change to Rate (uR/hr)

3. Test: Press and Hold [CLR/TEST]
   -Hold buttons until display changes to ".8.8.8" then release
   -10-second counting sequence
   -A flashing "9" indicates success

4. Device is Ready for use
   -Attach to PPE as appropriate

Suggested Alarm Levels

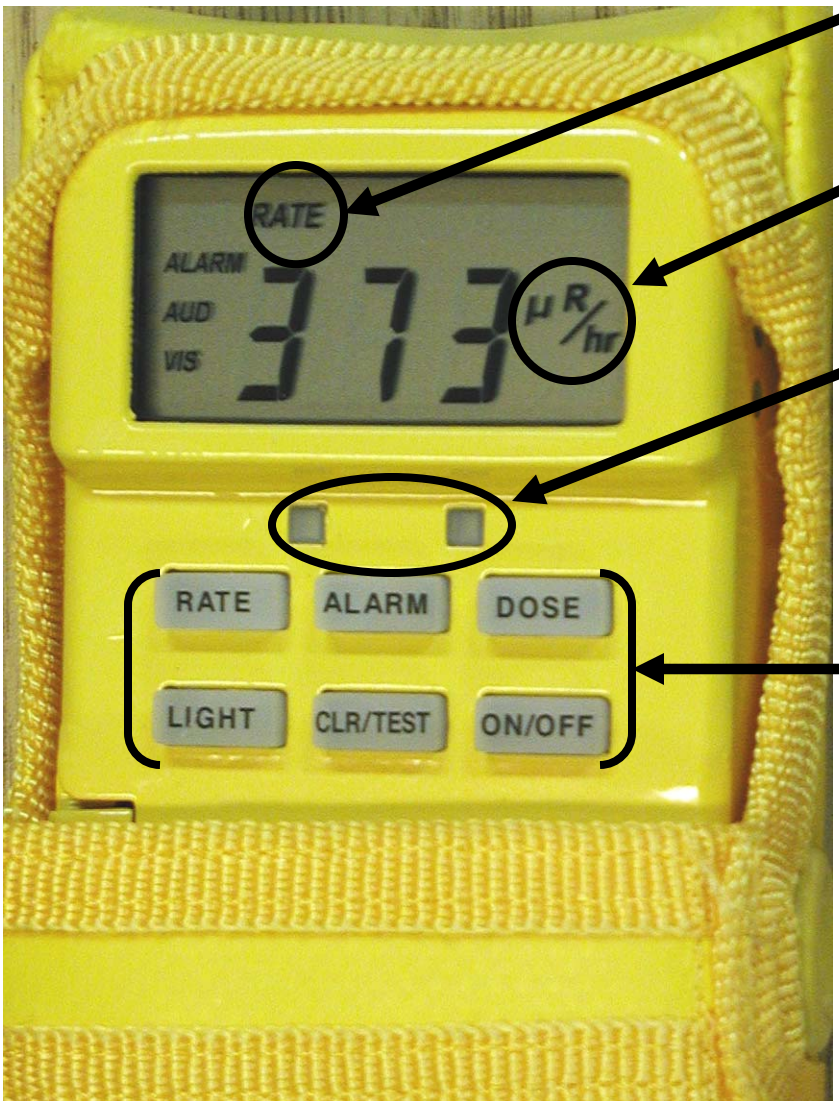
High Rate Alarm	**300 mR/hr***	**High Dose Alarm**	**20 R****
Low Rate Alarm	10 mR/hr	Low Dose Alarm	3 R

*Turn-Back Rate (OR Dept of Energy)
**Highest Dose Allowed – OR OSFM

ADVANCED OPTIONS

Check your "Stay-Time"

1. Push and Hold [ALARM]
   - This tells time you can stay in this radiation field



Mode Display indicates
RATE = Rate of Exposure
DOSE = Radiation Dose

Units are auto-displayed
μR/hr = micro R per hour
(U-R per hour)
Normal RATE level is ~10 μR/hr

Warning Lights
Left Light = Rate Alarm
Right Light = Dose Alarm

Button Functions:
RATE
1.Rate Mode (press)
2.Source Finder (press/hold)
3.Data Log [RATE+DOSE]
ALARM Shows Stay Time
DOSE Show's the worker's dose
LIGHT Lights display for 5 sec
CLR/TEST
1.Shut off **Alarms** (press)
2.QC Tests
See #3 in Start Up Instr
3.**Alarm Test**: During the test press [RATE] or [DOSE]
ON/OFF Power Button

PERSONNEL DOSIMETER TRACKING FORM

INCIDENT LOCATION _____

DATE _____ **AGENCY** _____

TRACKING OFFICER _____

Personnel	Individual Dosimeter	Initial Reading	Final Reading	Decon	Medical Screen	Total Dose
1.	Yes No					
2.	Yes No					
3.	Yes No					
4.	Yes No					
5.	Yes No					
6.	Yes No					
7.	Yes No					
8.	Yes No					
9.	Yes No					
10.	Yes No					
11.	Yes No					
12.	Yes No					
13.	Yes No					
14.	Yes No					
15.	Yes No					
16.	Yes No					

17.	Yes No					
18.	Yes No					
19.	Yes No					
20.	Yes No					
21.	Yes No					
22.	Yes No					
23.	Yes No					
24.	Yes No					
25.	Yes No					
26.	Yes No					
27.	Yes No					
28.	Yes No					
29.	Yes No					
30.	Yes No					
31.	Yes No					
32.	Yes No					
33.	Yes No					
34.	Yes No					
35.	Yes No					
36.	Yes No					
37.	Yes No					
38.	Yes No					
39.	Yes No					

RADIOISOTOPES

(Probable sources for RDD devices)

Isotope	Emission	½ life	Organ	Source - Form
Americium-241	Alpha, **Gamma**	433 yrs	Bone	Smk detect, well log, **nonmet solid**
Barium-140		13 days		
Cadmium-109	**Gamma**	462 days		Metal analysis
Calcium-47	Beta, **Gamma**	4.5 days		Medical research
Californium-244	Alpha, **Gamma**	18 yrs		Inspect luggage, moisture insp
Carbon-14	Beta	5730 yrs		Bio-research, pollution control
Cesium-137	Beta, **Gamma**	30 yrs	Total body	Food irrad, cancer ther - **powder**
Chromium-51	**Gamma**	28 days		Medical research
Cobalt-57	**Gamma**	272 days		Medical diagnostic
Cobalt-60	Beta, **Gamma**	5.3 days	Total body	Irradiation, cancer ther - **metal**
Copper-67	Beta, **Gamma**	2.6 days		Cancer treatment
Curium-244	Alpha, **Gamma**	18 yrs		Mining and drilling
Gallium-67	**Gamma**	3.3 days		Medical diagnostic
Iodine-123	**Gamma**	13 hours		Medical diagnostic
Iodine-125	**Gamma**	60 days		Medical diagnostic, research
Iodine-129	Beta, **Gamma**	15 mill yrs		Check radiation counters
Iodine-131	Beta, **Gamma**	8 days	Thyroid	Nuclear medicine
Iridium-192	Beta, **Gamma**	74 days	Lung	Ind radiography, cancer, **metal**
Iron-55	Alpha, **Gamma**	2.7 yrs		Industrial analysis, research
Krypton-85	Beta, **Gamma**	10.8 yrs		Industrial gauges, indicator lites
Nickel-63	Beta	100 yrs		Explosive detect, voltage regs
Phosphorus-32	Beta	14 days		Bio-medical research
Plutonium-238	Alpha, **Gamma**	88 yrs	Bone	Nuclear weapon, NASA power

Plutonium-239	Alpha, **Gamma**	24,000 yrs		Nuclear weapon
Polonium-212	Alpha, **Gamma**	138 days		Photographic film
Promethium-147	Beta, **Gamma**	2.6 yrs		Material gauges, thermostats
Radium-226	Alpha, beta, **Gamma**	1599 yrs	Bone	Dials, medical therapy
Radon-222		4 days		Environ level
Selenium-75	**Gamma**	120 days		Protein research
Sodium-24	Beta, **Gamma**	15 hours		
Spent Fuel	Alpha, Beta, **Gamma**			
Strontium-85	**Gamma**	65 days		Medical research
Strontium-90	Beta	29 yrs	Bone	Eye therapy - **ceramic**
Sulfur-35	Beta	87 days		Survey meters, med research
Technetium-99m		6 hrs		Diagnostic imaging
Thorium-234	Alpha, Beta, **Gamma**	24 days		
Tritium (H-3)	Beta	12 yrs	Total body	Exit signs
Uranium 235/38	Alpha, Beta, **Gamma**	15 days	Kidney	

RADIATION UNITS

Measure of	**Quantity**	**Unit**
Amnt of Rad material	Activity	Curie (Ci)
Ionization in air	Exposure	Roentgen (R)
Absorbed Energy per mass	Absorbed Dose	rad
Absorbed Dose by rad type	Dose Equivalent	rem

For most types of radiation 1 R = 1 rad = 1 rem

International Units

1 Gray = 100 Rads 1 Sievert = 100 Rems

Nuclear Terms

ALARA – "As Low As Reasonably Achievable" – a process to control or manage radiation exposure to individuals and releases of radioactive material to the environment. Ensures doses that are as low as social, technical, economic, practical and public welfare considerations permit.

Alpha – Particulate radiation, made up of two neutrons and two protons with a charge of +2. This particle can't penetrate turnouts or even the outer skin layer. Very damaging if inhaled or swallowed.

Beta – Particulate radiation, made up of single electrons with a charge of -1. Can't generally move far in air and are stopped by a thin sheet of aluminum but can penetrate the skin, causing burns.

Contamination – The deposition of particulate radioactive radiation on the surfaces of structures, areas, objects or people where it may be external or internal.

Curie – The traditional measure of radioactivity based on the observed decay rate of 1 gram of radium. One curie will have 37 billion disintegrations each second.

Exposure – Radiation energy that affects material, but unlike particulate radiation, does not cause contamination.

Gamma – High energy rays with a short wavelength. This energy can penetrate much farther than particulate radiation and is stronger than, but similar to X-Rays.

Half-life – The time any substance takes to decay by half of its original amount. A rule of thumb is after 10 half-lives, the amount of radioactivity left in the sample is negligible.

Ionizing Radiation – Any radiation capable of displacing electrons from atoms, thereby producing charged atoms or molecules (ions).

Isotope – A nuclide of an element having the same number of protons, but a different number of neutrons.

Neutron – A small atomic particle possessing no electrical charge and typically found within the nucleus. It has about the same mass as a proton.

Rad – A unit expressing the *absorbed dose* of ionizing radiation, or the energy deposited per unit mass. The units of rad and gray are the units in two different systems for expressing absorbed dose:

1 rad = 0.01 gray (Gy); 1 Gy = 100 rad

Rem – A unit of *absorbed dose* that accounts for the relative biological effectiveness of ionizing radiation in tissue (also called *equivalent dose*). The units of rem and sievert are the units in two different systems for expressing equivalent dose:

1 rem = 0.01 sieverts: 1 Sv = 100 rem

Roentgen – A unit of exposure to x-rays or gamma rays. The primary standard of measurement used by the US emergency responder community.

1,000 micro-roentgen (uR) = 1 milli-roentgen (mR)
1,000 milli-roentgen (mR) = 1 roentgen ®
1,000,000 uR = 1 R

Time/Distance/Shielding – Principles for radiation protection. Time is protection by limiting the time spent in close proximity to a source. Distance is protection that decreases exposure by the inverse square of the distance from the source. Shielding is the material between a source and the responder that reduces exposure, based on material type and thickness.

X-Ray – Electromagnetic radiation that can travel long distances through air and other materials.

RADIATION RESPONSE RESOURCES

1. **Civil Support Team (CST)**
2. **Oregon Emergency Response System (OERS)**
3. **National Response Center (NRC)**
4. **Radiological Assessment Program (RAP) (DOE)**
5. **Explosives Disposal Unit (EDU)**
6. **Radiological Protection Services (RPS)**
7. **Environmental Protection Agency (EPA)**
8. **Emergency Operations Center (EOC)**
9. **Federal Bureau of Investigation (FBI)**
10. **Interagency Modeling &Atmospheric Assessment Ctr (IMAAC)**