Lawrence Livermore National Laboratory

Job Aids for Using Preventive Radiological/Nuclear Detection Equipment for Consequence Management

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This is the Lawrence Livermore National Laboratory contribution to Task 4 for the project "First Responder Use of Preventive Radiological/Nuclear Detection (PRND) Equipment During Consequence Management Operations"

Executive Summary

The overall objective of this project is to research, evaluate, and test first responder preventive radiological/nuclear detection equipment (PRND) to provide state and local agencies with guidance on how to best use this equipment for response after a radiological/nuclear release or detonation. While the equipment being tested in this effort has been specifically designed for detection and interdiction operations, the fleet of PRND equipment can help fill critical needs for radiological instrumentation should a consequence management response take place. This document provides prototype job aids to help responders utilize this class of equipment for consequence management missions.

Example Job Aids were created for some of the most common body worn PRND equipment. Each job aid is meant to be fit on a 5x7 card (front and back) and uses a simplified table to describe how the piece of equipment might be used to support the consequence management mission space. See Appendix A for examples of the Job Aids created to date.

These Job Aids are the culmination of efforts conducted at several national laboratories and the Department of Homeland Security's (DHS) National Urban Science and Technology Laboratory (NUSTL). These efforts included:

- **Equipment Categorization** as defined in the ***Preventive Radiological/Nuclear Detection Equipment Categorization for Consequence Management***, Lawrence Livermore National Laboratory, LLNL-TR-732941, October 2017

- **Analysis of Consequence Management Missions**, as organized and reported in ***Mission Analysis for Using Preventive Radiological/Nuclear Detection Equipment for Consequence Management***, Lawrence Livermore National Laboratory, LLNL-TR-739806, October 2017

- **Testing of PRND Equipment** to determine the viability of use in consequence management missions, the results of which have been reported in the ***Evaluation of Preventative Radiological/Nuclear Detector Archetypes to Validate Repurpose to the Consequence Management Mission***, Brookhaven National Laboratory, BNL-114278-2017, September 2017.

- A Generic Job Aid for ***Using Preventative Radiological Nuclear Detection Equipment for Consequence Management Missions*** that contains an overview of the mission space and applicability of general categories of equipment was developed by Remote Sensing Laboratory, National Security Technologies, LLC.

- **An Update of ANSI Standards** related to PRND equipment is underway to reflect to application of their use in the consequence management mission led by Savannah River National Laboratory

- **A PRND equipment database** was compiled by Lawrence Livermore National Laboratory that contains detailed parameters and application information on over 200 pieces of equipment. A copy of this database will be provided to the Domestic Nuclear Detection Office's (DNDO's) Data Mining, Analysis and Modeling Cell (DMAMC) so that it can support community requests for information.

Introduction

The National Council of Radiation Protection and Measurements (NCRP) Report # 179[i] has identified that emergency workers at the scene of a radiological or nuclear emergency are not considered occupational workers (as defined by NRC[ii] and DOE[iii]) and that monitoring of emergency workers does not require any specific equipment or device. Alternate techniques or approaches may be used for determining their dose, including the use of PRND equipment.

"Existing radiation detection equipment used for interdiction can be repurposed for use in consequence and dose management provided planning is performed to ensure the equipment does not exceed the operational range."

The Job Aids in this report are meant to inform the use of PRND equipment for a variety of consequence management missions, including worker exposure control and dose monitoring in the early phase of a radiological emergency when there will be limited capabilities at the scene of the incident.

A general (non-instrument specific) Job Aid called ***Using Preventative Radiological Nuclear Detection Equipment for Consequence Management Missions*** was developed by the Remote Sensing Laboratory under the auspices of this DHS NUSTL effort. This ~40 page spiral bound flip book contains blank, "fill in" questions so that any instrument can be evaluated for use in consequence management missions. It also contains helpful references, conversion factors, and instructions on the use of the RadResponder Network (https://www.radresponder.net/).

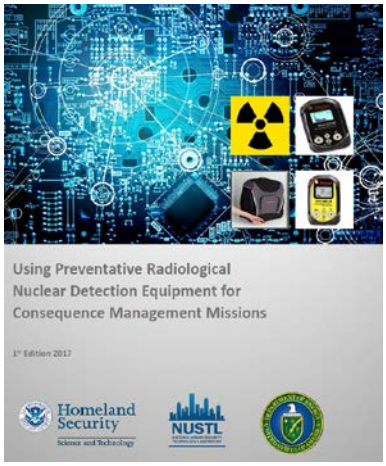


Figure 1: Non-instrument specific Job Aid developed by Remote Sensing Laboratory

In contrast, the job aids described in this report are meant to be fit on a single 5x7 card (front and back), utilizing a simplified table to describe how the equipment can be used for consequence management missions and what operational limits exist. Instrument specific amplifying information is provided on the back the of the card. See Appendix A for examples of the Job Aids created to date.

Summary of PRND Equipment Category Definitions

The focus of these job aids is on the "Body Worn" Category in Table 1. Categories were established in the Preventive Radiological/Nuclear Detection Equipment Categorization for Consequence Management[iv] report. The categories of Personal Emergency Radiation Detectors (PERD) & Monitors and Electronic Personal Dosimeter (EPD) are technically not PRND equipment, but are included in the table because they are often mistaken as PRND equipment.

Table 1: Summary of Equipment Categorization

	Category	Defining Characteristics	Mission Applicability
Body worn	Personal Radiation Detector (PRD)	Highly sensitive, can detect small changes from background, alarming, body worn device capable of passing low exposure rate tests of ANSI N42.32, typically uses scintillation detectors.	PRND: Detection of low level radiation for contraband investigation. CM: Environmental and personnel contamination surveys in Cold Zone
	Spectroscopic Personal Radiation Detector (SPRD)	Highly sensitive, can detect and identify low levels of radiation, alarming, body worn device capable of passing low exposure rate tests of ANSI N42.48, typically uses scintillation detectors	PRND: Detection and identification of low level radiation for contraband investigation. CM: Environmental and personnel contamination surveys in Cold Zone, Radionuclide ID.
	Extended Range Personal Radiation Detector (ER-PRD)	Extended range, alarming, body worn device capable of passing low exposure rate tests of ANSI N42.32, but has an extended capability to measure up to 10 R/h or more.	PRND: Detection of low level radiation for contraband investigation. CM: Cold and Hot Zone Survey and responder exposure control.
	Personal Emergency Radiation Detectors (PERD) & Monitors	High range, alarming, body worn device capable of operating in harsh environments and capable of operating above 10 R/h, potentially up to 1,000 R/h (ANSI N42.49A)	CM: Detection and entry into Hot Zone, Exposure control and possibly dose monitoring tool.
	Electronic Personal Dosimeter (EPD)	High range, alarming, body worn device for occupational workers to measure personal dose equivalence for regulatory compliance. Performance requirements can be found in ANSI N42.20.	CM: Hot Zone detection, responder exposure control and dose monitoring tool if ruggedized

PERSONAL RADIATION DETECTOR (PRD)

An alarming personal radiation detector worn on the body to detect photon (and in some cases neutron) radiation. The device should be capable of passing the radiological performance tests indicated in ANSI N42.32 for gamma radiation, especially the ability to alarm at low exposure rates 50 µR/h. Typical devices will use a highly sensitive scintillator detector (e.g., CLYC, sodium iodide [NaI] and cesium iodide [CsI]).

EXTENDED RANGE PERSONAL RADIATION DETECTOR (ER-PRD)

An alarming personal radiation detector worn on the body to detect photon (and in some cases neutron) radiation that uses 2 detection elements or circuitry techniques for both low and high level exposure ranges. The device should still be capable of passing the radiological performance tests indicated in ANSI N42.32 for gamma radiation, with the additional capability to measure exposure rates up to 10 R/h. Typical devices will use both a highly sensitive scintillator detector (e.g., CLYC, sodium iodide [NaI] and cesium iodide [CsI]) and a secondary detector (typically solid state or GM detector) for the measuring higher exposure rates, often above 10 R/hr.

SPECTRASCOPIC PERSONAL RADIATION DETECTOR (SPRD)

An alarming personal radiation detector worn on the body to detect photon (and in some cases neutron) radiation and identify the type of radioactive material through gamma ray spectral analysis. The device should be capable of passing the radiological performance tests indicated in ANSI N42.48 for gamma radiation, especially the ability to alarm at low exposure rates 50 µR/h and identify radionuclides. Typical devices will use a highly sensitive scintillator detector (e.g., CLYC, sodium iodide [NaI] and cesium iodide [CsI]).

PERSONAL EMERGENCY RADIATION DETECTORS (PERDS) & MONITORS

An alarming personal radiation detector worn on the body to detect photons and alarm if preset thresholds for either exposure rate or accumulated dose are exceeded. It is designed to be used in harsh environment with high exposures rates (> 10 R/h) for emergency response applications. The ANSI standard the PERD, N42.49A (ANSI, 2011), is fairly recent and not many manufactures have tested their devices to this standard. The standard for survey meters, ANSI-N42.33-2006 is often used instead.

Overview of Mission Analysis

The ***Mission Analysis for Using Preventive Radiological/Nuclear Detection Equipment for Consequence Management report***[v] defines key mission areas of interest to consequence management and provides an initial assessment of how the PRND equipment categories may be able to support the consequence management missions. This required the definition of several zones that were used to create the Job Aids:

Cold Zone

This is the area outside of the Hot Zone. There may be some contamination and elevated radiation in this area, but it is below the levels indicated for controlled access. e.g. a Hot Line. For a large incident, the Cold Zone may include areas where protective actions are in place, such as agricultural embargo. There may also be a response agency defined Warm Zone as a transition area between Hot and Cold Zones.

Hot Zone

The NCRP[vi] identifies the Hot Zone boundary by exposure rate or surface contamination levels, > 10 mR/h, 60,000 dpm/cm2 beta/gamma surface contamination, or 6,000 dpm/cm2 for alpha surface contamination.

Dangerous Radiation Zone

The NCRP[vi] defines a Dangerous Radiation Zone (DRZ) where exposure rate exceeds 10 R/h (10,000 mR/h), within which, actions taken should be restricted to time-sensitive, mission-critical activities, such as lifesaving.

Mission Requirements

CM response mission areas were mapped to four radiological detection and measurement equipment capabilities:

Worker Exposure Control – For photon energies most likely to be encountered in an emergency, the capability to warn the user he/she was approaching or have entered the Hot Zone or the Dangerous Radiation Zone.

Worker Dose Monitoring – The capability to measure integrated exposure or dose and alarm when predetermined levels are exceeded.

Radiation Survey – Instruments that have the capability to display exposure or dose rate can be used to warn the approach to or establish the boundary of a radiation hazard zone or project accumulated dose.

Person/Object External Contamination Detection (γ) – The capability to determine if the contamination on a person or object exceeds predetermined criteria. For this mission, sensitivity is important. The device should be able to detect low levels of contamination on a person or object. In a large-scale event, an initial screening level of 1 µCi of Cesium-137 spot contamination is considered acceptable[1]. Equipment that could effectively detect 0.1 mR/h could also be used for higher contamination levels, but this would be considered marginal.

Testing at Brookhaven National Laboratories[vii] demonstrated that many PRDs could be used to detect 1 µCi of Cs-137 spot contamination at a distance of 2 inches from the surface of clothing, skin, or object surveying at a speed of 12 inches s^{-1}. The PRND equipment for CM Job Aids list the appropriate survey height and speed useful for finding 1 µCi of Cs-137 as demonstrated through testing. Untested

[1] Screening level identified in National Council on Radiation Protection and Measurement. (2011), "Responding to a Radiological or Nuclear Terrorism Incident: A Guide for Decision Makers". Report No. 165, ISBN 978-0-9823843-3-6, December 31, 2010. This is also the "Fixed + Loose" contamination screening level found in ***Background Information on Fema-Rep-22: Contamination Monitoring Guidance for Portable Instruments Used for Radiological Emergency Response to Nuclear Power Plant Accidents.*** See Appendix 2 of ***Mission Analysis for Using Preventive Rad/Nuc Detection Equipment for Consequence Management*** report for more information.

equipment will list presumed survey height and speed based on how closely the equipment matches tested equipment's sensitivity and specifications.

PRND Equipment for CM Job Aids

Example Job Aids were created for some of the most common body worn PRND equipment. Each job aid is meant to be fit on a 5x7 card (front and back) and uses a simplified table to describe how the piece of equipment may be applied within the consequence management mission space. See Figure 2 for an example of the front side of a card.

Prominently displayed on the front of the card is a scale and arrow indicating the maximum exposure (or dose) rate detected by the instrument. Color coding is used to designate if the instrument can be used in the Hot Zone (light Purple) or Dangerous Radiation Zone (dark purple).

Also displayed is a table describing the instrument's applicability for various missions and operational zones. Note that some missions are not appropriate in certain zones; these table cells are "greyed out," e.g., it is not appropriate to do a radiation survey mission in the dangerous radiation zone, nor is it suitable to conduct contamination screening in either the Hot Zone of Dangerous Radiation Zone.

Instrument capability for a given mission and zone is indicated as:

- Appropriate (■): This is a device that can be used effectively to perform the designated mission or task without modification of the device or of the normal mode of employment. The device was designed or intended for that mission or task.
- Marginal (○): The device can provide useful and relevant data in support of the designated mission or task, but with modification to the normal mode of employment. In addition, its use may create a potentially unsafe condition for the user of the device. This implies a need for understanding the device limitations and care in the interpretation of the data produced by such a device under the circumstances.
- Insufficient (⦸): While the device is capable of detecting radiation, its technical performance characteristics or conditions of use are such that it is unlikely to be able to provide useful information in support of the designated mission or task. In addition, its use may create an unsafe condition for the user of the device.

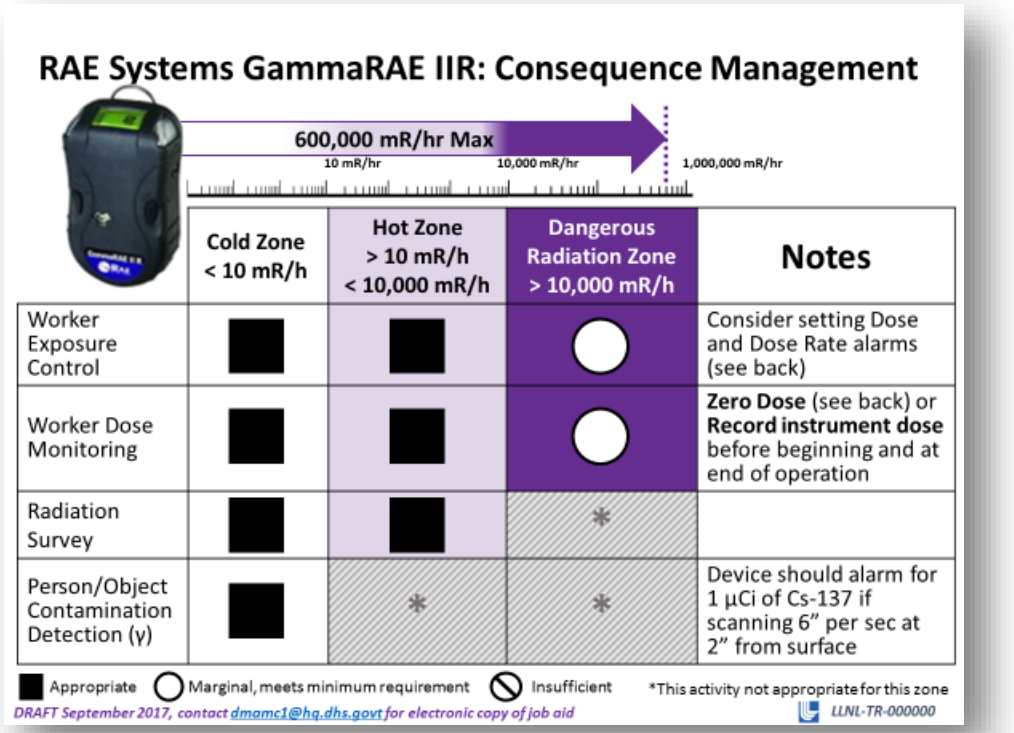
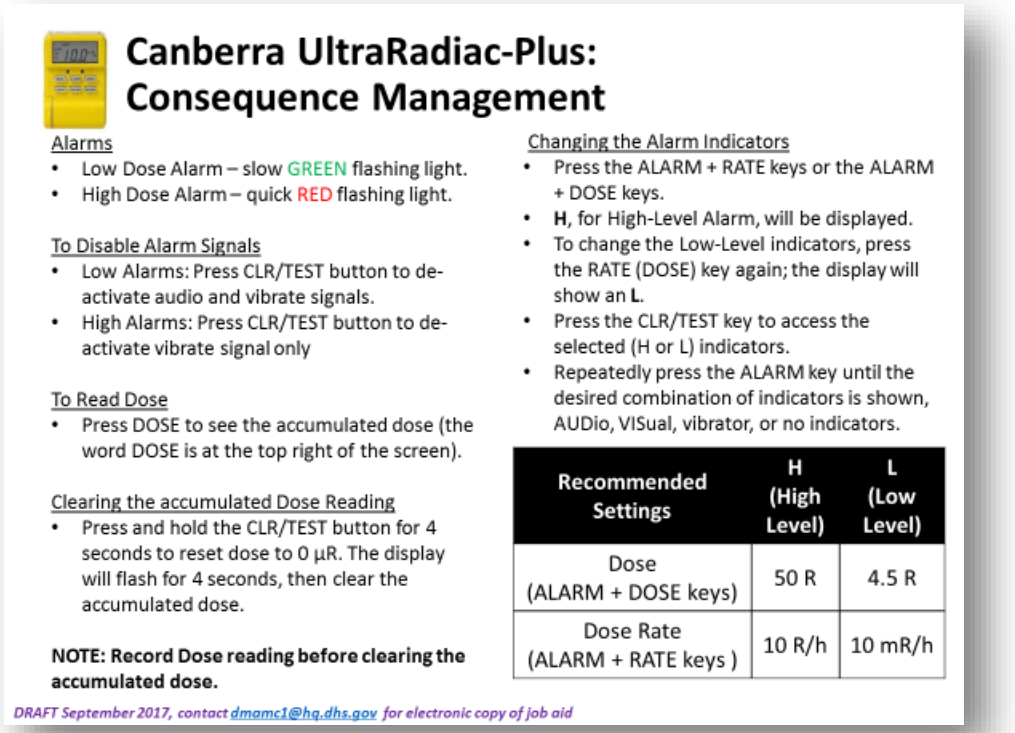


Figure 2: Example of Job Aid (Front)

The information on the back of the card will depend on the instrument's capabilities. For example, if the instrument has the ability to record integrated exposure information, information will be provided on how to read this information and (if allowed) reset the accumulated exposure.

If the instrument has field settable alarms, information is provided on how to set the alarms. Figure 3 provides an example of how to read the dose and change alarms on a Canberra Ultra Radiac.

Note: Job Aid equipment alarm setting options and instructions were obtained from operating manuals current at the time of their generation and may differ for the varying firmware versions loaded on a given make/model.



Canberra UltraRadiac-Plus: Consequence Management

Alarms
- Low Dose Alarm – slow GREEN flashing light.
- High Dose Alarm – quick RED flashing light.

To Disable Alarm Signals
- Low Alarms: Press CLR/TEST button to de-activate audio and vibrate signals.
- High Alarms: Press CLR/TEST button to de-activate vibrate signal only

To Read Dose
- Press DOSE to see the accumulated dose (the word DOSE is at the top right of the screen).

Clearing the accumulated Dose Reading
- Press and hold the CLR/TEST button for 4 seconds to reset dose to 0 µR. The display will flash for 4 seconds, then clear the accumulated dose.

NOTE: Record Dose reading before clearing the accumulated dose.

Changing the Alarm Indicators
- Press the ALARM + RATE keys or the ALARM + DOSE keys.
- **H**, for High-Level Alarm, will be displayed.
- To change the Low-Level indicators, press the RATE (DOSE) key again; the display will show an **L**.
- Press the CLR/TEST key to access the selected (H or L) indicators.
- Repeatedly press the ALARM key until the desired combination of indicators is shown, AUDio, VISual, vibrator, or no indicators.

Recommended Settings	H (High Level)	L (Low Level)
Dose (ALARM + DOSE keys)	50 R	4.5 R
Dose Rate (ALARM + RATE keys)	10 R/h	10 mR/h

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Figure 3: Example of Canberra UltraRadiac Job Aid (Back Page)

Emergency workers operate under reference values and guidelines rather than regulatory dose limits while working in an emergency exposure situation. Default alarm set points are provided that correlate to national and international reference values and guidelines for emergency response. It is expected that many agencies will have alternate alarm set points defined by internal policy. The Job Aids are being provided in an editable PowerPoint format so that users may change the Job Aids to match their policies.

Exposure Rate Alarms:

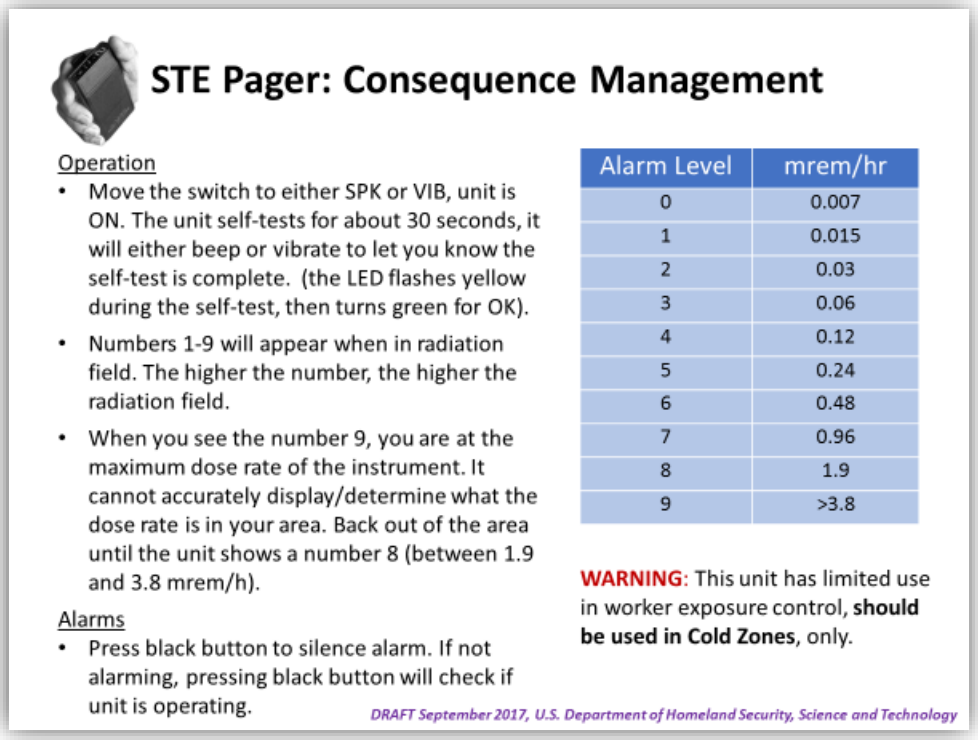
- Low Level 10 mR/h (0.01 R/h) is used to identify the ***hot line*** (ASTM[viii]), ***outer perimeter***[vi] , or 0.01 R/h boundary[ix] of the Hot Zone[vi, x] or Low Radiation Zone[xi]
- High level 10 R/h represents the boundary to the Dangerous Radiation Zone[vi] or Dangerous Fallout Zone[ix]

Total Exposure Alarms:

- The 4.5 R low level alarm is **~90% of the 5 rem** standard dose limit for **non-emergency** activities (OSHA[xii], NRC, and DOE). 90% was the chosen alarm level to provide opportunity for the responder to leave the exposure area without exceeding the 5 rem limit. Even in emergency situations, exceeding the 5 rem guideline should only be done when critical, time sensitive missions are required and all appropriate actions are taken to reduce dose.

- The 50 R high level alarm is from the National Council of Radiation Protection and Measurement Report # 165 which states: "When the cumulative absorbed dose to an emergency responder reaches 50 rad (0.5 Gy), a decision be made on whether or not to withdraw the emergency responder from the hot zone. NCRP considers the 50 rad (0.5 Gy) cumulative absorbed dose a decision dose, not a dose limit."

If the equipment does not have adjustable alarms, then different information will be displayed. For example, the STE Pager does not have adjustable alarms and does not even provide an exposure rate readout. Because of this, the back page of the Job Aid offers a conversion chart to help the user interpret the 1 through 9 readout to approximate dose rates (see Figure 4)



STE Pager: Consequence Management

Operation

- Move the switch to either SPK or VIB, unit is ON. The unit self-tests for about 30 seconds, it will either beep or vibrate to let you know the self-test is complete. (the LED flashes yellow during the self-test, then turns green for OK).
- Numbers 1-9 will appear when in radiation field. The higher the number, the higher the radiation field.
- When you see the number 9, you are at the maximum dose rate of the instrument. It cannot accurately display/determine what the dose rate is in your area. Back out of the area until the unit shows a number 8 (between 1.9 and 3.8 mrem/h).

Alarms

- Press black button to silence alarm. If not alarming, pressing black button will check if unit is operating.

Alarm Level	mrem/hr
0	0.007
1	0.015
2	0.03
3	0.06
4	0.12
5	0.24
6	0.48
7	0.96
8	1.9
9	>3.8

WARNING: This unit has limited use in worker exposure control, **should be used in Cold Zones**, only.

DRAFT September 2017, U.S. Department of Homeland Security, Science and Technology

Figure 4: Example of STE Pager Job Aid (Back Page)

[i] National Council on Radiation Protection and Measurement, "Guidance for Emergency Response Dosimetry". Report No. 179, *Currently pre-publication* (estimated 2017).

[ii] See 10 CFR Part 20 for guidance on NRC occupational workers

[iii] See 10 CFR Part 835 for guidance on DOE occupational workers

[iv] Brooke Buddemeier, Annmarie Wood-Zika, Stephen Musolino, Gladys Klemic. Preventive Rad/Nuc Detection Equipment Categorization for Consequence Management, Lawrence Livermore National Laboratory, LLNL-TR-732941, October 2017.

[v] Brooke Buddemeier, Annmarie Wood-Zika. Mission Analysis for Using Preventive Rad/Nuc Detection Equipment for Consequence Management, Lawrence Livermore National Laboratory, LLNL-TR-690681, October 2017

[vi] National Council on Radiation Protection and Measurement. (2011), "Responding to a Radiological or Nuclear Terrorism Incident: A Guide for Decision Makers". Report No. 165, ISBN 978-0-9823843-3-6, December 31, 2010.

[vii]Stephen V. Musolino, Brooke Buddemeier, Charles Finfrock, Jose Gomera, Gladys Klemic, Joseph Moskowitz, Thomas Roberts, Lance Schaefer; Evaluation of Preventative Radiological/Nuclear Detector Archetypes to Validate Repurpose to the Consequence Management Mission, Brookhaven National Laboratory, BNL-114278-2017, September 2017.

[viii] ASTM E2601-15, Standard Practice for Radiological Emergency Response, http://www.astm.org/cgi-bin/resolver.cgi?E2601, ASTM International, West Conshohocken, PA, 2008, www.astm.org

[ix] Executive Office of the President Homeland Security Council Interagency Policy Coordination subcommittee for Preparedness and Response to Radiological and Nuclear Threats, Planning Guidance for Response to a Nuclear Detonation (June 2010). Office of Science and Technology Policy, available at www.ostp.gov

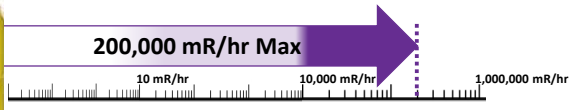
[x] ASTM E2601-15, Standard Practice for Radiological Emergency Response, http://www.astm.org/cgi-bin/resolver.cgi?E2601, ASTM International, West Conshohocken, PA, 2008, www.astm.org

[xi] CRCPD Publication 06-6, Handbook for Responding to a Radiological Dispersal Device: First Responders Guide – The First 12 Hours, Conference of Radiation Control Program Directors, September 2006, www.crcpd.org

[xii] See 29 CFR Part 1910.1096 (Ionizing Radiation) for OSHA's occupational limit. Under the OSHA Ionizing Radiation standard, the annual occupational limit for whole body radiation exposure for adults (age ≥18 years) is 5 rem (50 mSv)

Appendix 1: Example Job Aids

UltraRadiac-Plus: Consequence Management



	Cold Zone < 10 mR/h	Hot Zone > 10 mR/h < 10,000 mR/h	Dangerous Radiation Zone > 10,000 mR/h	Notes
Worker Exposure Control	■	■	○	Consider setting Dose and Dose Rate alarms (see back)
Worker Dose Monitoring	■	■	○	**Zero Dose** (see back) or **Record your dose** before beginning and end of operation
Radiation Survey	■	■	*	
Person/Object Contamination Detection (β/γ)	⊘	*	*	Device is NOT expected to alarm for 1 µCi of Cs-137 if scanning 12" per sec at 2" from surface

■ Appropriate ○ Marginal, meets minimum requirement ⊘ Insufficient *This activity not appropriate for this zone

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Lawrence Livermore National Laboratory developed this DRAFT Job Aid for the Department of Homeland Security's National Urban Science and Technology Laboratory "First Responder Use of Preventive Radiological/Nuclear Detection (PRND) Equipment During Consequence Management Operations" project. For more information, contact Benjamin Stevenson <Benjamin.Stevenson@hq.dhs.gov> or Brooke Buddemeier <buddemeier1@llnl.gov>

Cold Zone: This is the area outside of the Hot Zone. There may be some contamination and elevated radiation in this area, but it is below the levels indicated for controlled access. e.g. a Hot Line. For a large incident, the Cold Zone may include areas where protective actions are in place, such as agricultural embargo. There may also be a response agency defined Warm Zone as a transition area between Hot and Cold Zones.
Hot Zone: The NCRP* identifies the Hot Zone boundary by exposure rate or surface contamination levels, > 10 mR/h.
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*National Council on Radiation Protection and Measurement. (2011), "Responding to a Radiological or Nuclear Terrorism Incident: A Guide for Decision Makers". Report No. 165, ISBN 978-0-9823843-3-6, December 31, 2010.

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Dose Rate (ALARM + RATE keys)	10 R/h	10 mR/h

DRAFT September 2017, contact dmamc1@hq.dhs.gov for electronic copy of job aid

Emergency workers operate under reference values and guidelines rather than regulatory dose limits while working in an emergency exposure situation. Default alarm set points are provided that correlate to national and international reference values and guidelines for emergency response. It is expected that many agencies will have alternate alarm set points defined by internal policy and the Job Aids are being provided in an editable PowerPoint format so that they may change the Job Aids to match their policies.

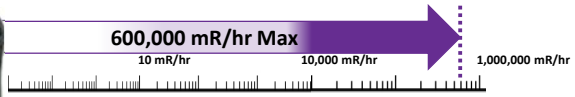
Exposure Rate Alarms:
- Low Level 10 mR/h (0.01 R/h) is used to identify the ***hot line*** (ASTM), ***outer perimeter***[iii] , or 0.01 R/h boundary of the Hot Zone[iii], or Low Radiation Zone
- High level 10 R/h represents the boundary to the Dangerous Radiation Zone[ix] or Dangerous Fallout Zone[vi]

Total Exposure Alarms:
- The 4.5 R low level alarm is **~90% of the 5 rem** standard dose limit for **non-emergency** activities (OSHA, NRC, and DOE). 90% was the chosen alarm level to provide opportunity for the responder to leave the exposure area without exceeding the 5 rem limit. Even in emergency situations, exceeding the 5 rem guideline should only be done when critical, time sensitive missions are required and all appropriate actions are taken to reduce dose.
- The 50 R high level alarm is from the National Council of Radiation Protection and Measurement Report # 165 which states: "When the cumulative absorbed dose to an emergency responder reaches 50 rad (0.5 Gy), a decision be made on whether or not to withdraw the emergency responder from the hot zone. NCRP considers the 50 rad (0.5 Gy) cumulative absorbed dose a decision dose, not a dose limit."
- It is expected that individual agencies may have different alarm set points and the Job Aids will be distributed in an editable format so they can be adjusted to match agency policies.

References:

- ASTM E2601-15, Standard Practice for Radiological Emergency Response, http://www.astm.org/cgi-bin/resolver.cgi?E2601, ASTM International, West Conshohocken, PA, 2008, www.astm.org
- Executive Office of the President Homeland Security Council Interagency Policy Coordination subcommittee for Preparedness and Response to Radiological and Nuclear Threats, Planning Guidance for Response to a Nuclear Detonation (June 2010). Office of Science and Technology Policy, available at www.ostp.gov
- CRCPD Publication 06-6, Handbook for Responding to a Radiological Dispersal Device: First Responders Guide – The First 12 Hours, Conference of Radiation Control Program Directors, September 2006, www.crcpd.org
- 29 CFR Part 1910.1096 (Ionizing Radiation) for OSHA's occupational limit. Under the OSHA Ionizing Radiation standard, the annual occupational limit for whole body radiation exposure for adults (age ≥18 years) is 5 rem (50 mSv)

RAE Systems GammaRAE IIR: Consequence Management



	Cold Zone < 10 mR/h	Hot Zone > 10 mR/h < 10,000 mR/h	Dangerous Radiation Zone > 10,000 mR/h	Notes
Worker Exposure Control	■	■	○	Consider setting Dose and Dose Rate alarms (see back)
Worker Dose Monitoring	■	■	○	**Zero Dose** (see back) or **Record instrument dose** before beginning and at end of operation
Radiation Survey	■	■	*	
Person/Object Contamination Detection (γ)	■	*	*	Device should alarm for 1 µCi of Cs-137 if scanning 6" per sec at 2" from surface

■ Appropriate ○ Marginal, meets minimum requirement ⊘ Insufficient *This activity not appropriate for this zone

DRAFT September 2017, contact dmamc1@hq.dhs.govt for electronic copy of job aid LLNL-TR-000000

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Cold Zone: This is the area outside of the Hot Zone. There may be some contamination and elevated radiation in this area, but it is below the levels indicated for controlled access. e.g. a Hot Line. For a large incident, the Cold Zone may include areas where protective actions are in place, such as agricultural embargo. There may also be a response agency defined Warm Zone as a transition area between Hot and Cold Zones.
Hot Zone: The NCRP* identifies the Hot Zone boundary by exposure rate or surface contamination levels, > 10 mR/h.
Dangerous Radiation Zone: The NCRP defines a Dangerous Radiation Zone (DRZ) where exposure rate exceeds 10 R/h (10,000 mR/h), within which, actions taken should be restricted to time-sensitive, mission-critical activities, such as lifesaving.

Worker Exposure Control – For photon energies most likely to be encountered in an emergency, the capability to warn the user he/she was approaching or have entered the Hot Zone or the Dangerous Radiation Zone.
Worker Dose Monitoring – The capability to measure integrated exposure or dose and alarm when predetermined levels are exceeded.
Radiation Survey – Instruments that have the capability to display exposure or dose rate can be used to warn the approach to or establish the boundary of a radiation hazard zone or project accumulated dose.
Person/Object External Contamination Detection (γ) – The capability to determine if the contamination on a person or object exceeds predetermined criteria. For this mission, sensitivity is important. The device should be able to detect low levels of contamination on a person or object. In a large-scale event, initial screening levels 1 µCi of Cs-137 spot contamination are considered acceptable. Equipment that could effective 0.1 mR/h could also be used for higher contamination levels, but this would be considered marginal. Testing a Brookhaven National Laboratories, demonstrated that many PRDs could be used to detect 1 µCi of Cs-137 spot contamination at a distance of 2 inches from the surface of clothing, skin, or object and move it at a speed of 12 inches s^{-1} (However this device required a slower 6"/sec speed to ensure detection). The Job Aids of the tested equipment will list the appropriate survey height and speed useful for finding 1 µCi of Cs-137 as demonstrated through testing. Untested equipment will list presumed survey height and speed based on how closely the equipment matches tested equipment's sensitivity and specifications.

*National Council on Radiation Protection and Measurement. (2011), "Responding to a Radiological or Nuclear Terrorism Incident: A Guide for Decision Makers". Report No. 165, ISBN 978-0-9823843-3-6, December 31, 2010.

GammaRAE IIR: Consequence Management

To Change Alarm set points

- Press the MODE and SET button simultaneously for 3 sec., enter password.
  - SET button increases number,
  - MODE button moves to next digit,
  - press OK when you are finished.
- The MODE button moves you through the menu.
- Select Alarms
  - use the MODE button to highlight desired alarm or alert,
  - press the SET button to select it.
  - Use the MODE button to scroll through the menu.
- Select Quit to return to normal operating mode.

Clear Dose Reading

- Press MODE button repeatedly, until DOSE screen appears, then press the SET button twice.

NOTE: Record Dose reading before clearing the accumulated dose.

Recommended Alarm Settings[1]	High Level	Low Level
Dose	50 R	4.5 R
Dose Rate	10 R/h	10 mR/h

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Emergency workers operate under reference values and guidelines rather than regulatory dose limits while working in an emergency exposure situation. Default alarm set points are provided that correlate to national and international reference values and guidelines for emergency response. It is expected that many agencies will have alternate alarm set points defined by internal policy and the Job Aids are being provided in an editable PowerPoint format so that they may change the Job Aids to match their policies.

Exposure Rate Alarms:

- Low Level 10 mR/h (0.01 R/h) is used to identify the ***hot line*** (ASTM), ***outer perimeter*** , or 0.01 R/h boundary of the Hot Zone, or Low Radiation Zone
- High level 10 R/h represents the boundary to the Dangerous Radiation Zone or Dangerous Fallout Zone

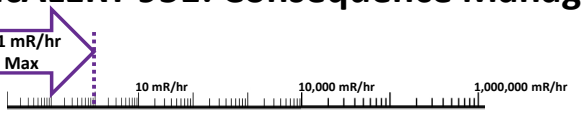
Total Exposure Alarms:

- The 4.5 R low level alarm is **~90% of the 5 rem** standard dose limit for **non-emergency** activities (OSHA, NRC, and DOE). 90% was the chosen alarm level to provide opportunity for the responder to leave the exposure area without exceeding the 5 rem limit. Even in emergency situations, exceeding the 5 rem guideline should only be done when critical, time sensitive missions are required and all appropriate actions are taken to reduce dose.
- The 50 R high level alarm is from the National Council of Radiation Protection and Measurement Report# 165 which states: "When the cumulative absorbed dose to an emergency responder reaches 50 rad (0.5 Gy), a decision be made on whether or not to withdraw the emergency responder from the hot zone. NCRP considers the 50 rad (0.5 Gy) cumulative absorbed dose a decision dose, not a dose limit."
- It is expected that individual agencies may have different alarm set points and the Job Aids will be distributed in an editable format so they can be adjusted to match agency policies.

References:

- ASTM E2601-15, Standard Practice for Radiological Emergency Response, http://www.astm.org/cgi-bin/resolver.cgi?E2601, ASTM International, West Conshohocken, PA, 2008, www.astm.org
- Executive Office of the President Homeland Security Council Interagency Policy Coordination subcommittee for Preparedness and Response to Radiological and Nuclear Threats, Planning Guidance for Response to a Nuclear Detonation (June 2010). Office of Science and Technology Policy, available at www.ostp.gov
- CRCPD Publication 06-6, Handbook for Responding to a Radiological Dispersal Device: First Responders Guide – The First 12 Hours, Conference of Radiation Control Program Directors, September 2006, www.crcpd.org
- 29 CFR Part 1910.1096 (Ionizing Radiation) for OSHA's occupational limit. Under the OSHA Ionizing Radiation standard, the annual occupational limit for whole body radiation exposure for adults (age ≥18 years) is 5 rem (50 mSv)

BNC NucALERT 951: Consequence Management



	Cold Zone < 10 mR/h	Hot Zone > 10 mR/h < 10,000 mR/h	Dangerous Radiation Zone > 10,000 mR/h	Notes
Worker Exposure Control	◯	⊘	⊘	Cold Zone usage, only
Worker Dose Monitoring	⊘	⊘	⊘	
Radiation Survey	⊘	⊘	*	
Person/Object Contamination Detection (γ)	■	*	*	Device should alarm for 1 µCi of Cs-137 if scanning 12" per sec at 2" from surface

■ Appropriate ◯ Marginal, meets minimum requirement ⊘ Insufficient *This activity not appropriate for this zone

DRAFT September 2017, contact dmamc1@hq.dhs.govt for electronic copy of job aid LLNL-TR-000000

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Hot Zone: The NCRP* identifies the Hot Zone boundary by exposure rate or surface contamination levels, > 10 mR/h.
Dangerous Radiation Zone: The NCRP defines a Dangerous Radiation Zone (DRZ) where exposure rate exceeds 10 R/h (10,000 mR/h), within which, actions taken should be restricted to time-sensitive, mission-critical activities, such as lifesaving.

Worker Exposure Control – For photon energies most likely to be encountered in an emergency, the capability to warn the user he/she was approaching or have entered the Hot Zone or the Dangerous Radiation Zone.
Worker Dose Monitoring – The capability to measure integrated exposure or dose and alarm when predetermined levels are exceeded.
Radiation Survey – Instruments that have the capability to display exposure or dose rate can be used to warn the approach to or establish the boundary of a radiation hazard zone or project accumulated dose.
Person/Object External Contamination Detection (γ) – The capability to determine if the contamination on a person or object exceeds predetermined criteria. For this mission, sensitivity is important. The device should be able to detect low levels of contamination on a person or object. In a large-scale event, initial screening levels 1 µCi of Cs-137 spot contamination are considered acceptable. Equipment that could effective 0.1 mR/h could also be used for higher contamination levels, but this would be considered marginal. Testing a Brookhaven National Laboratories, demonstrated that many PRDs could be used to detect 1 µCi of Cs-137 spot contamination at a distance of 2 inches from the surface of clothing, skin, or object and move it at a speed of 12 inches s^{-1}. The Job Aids of the tested equipment will list the appropriate survey height and speed useful for finding 1 µCi of Cs-137 as demonstrated through testing. Untested equipment will list presumed survey height and speed based on how closely the equipment matches tested equipment's sensitivity and specifications.

*National Council on Radiation Protection and Measurement. (2011), "Responding to a Radiological or Nuclear Terrorism Incident: A Guide for Decision Makers". Report No. 165, ISBN 978-0-9823843-3-6, December 31, 2010.

BNC NucALERT 951: Consequence Management

Operation

- Move ON button to either the Speaker (Spk) or Vibrate (Vib) position.
- The instrument self-tests for about 30 sec., it will either beep or vibrate to let you know that the self-test is complete.
- Numbers 1-9 will appear when in a radiation field. The higher the number, the higher the radiation field.
- When you see the number 9, you are above 1.1 mrem/h. It cannot accurately display/determine what the dose rate is in your area. Back out of the area until the unit shows a number 8 (between 0.6 and 1.1 mrem/h).

Alarm Level	mrem/hr
1	0.035
2	0.040
3	0.055
4	0.065
5	0.100
6	0.200
7	0.350
8	0.600
9	>1.100

WARNING: This unit has limited use in worker exposure control.

Note: *older versions of this model may display "H" when the unit overloads at ~13 mrem/hr*

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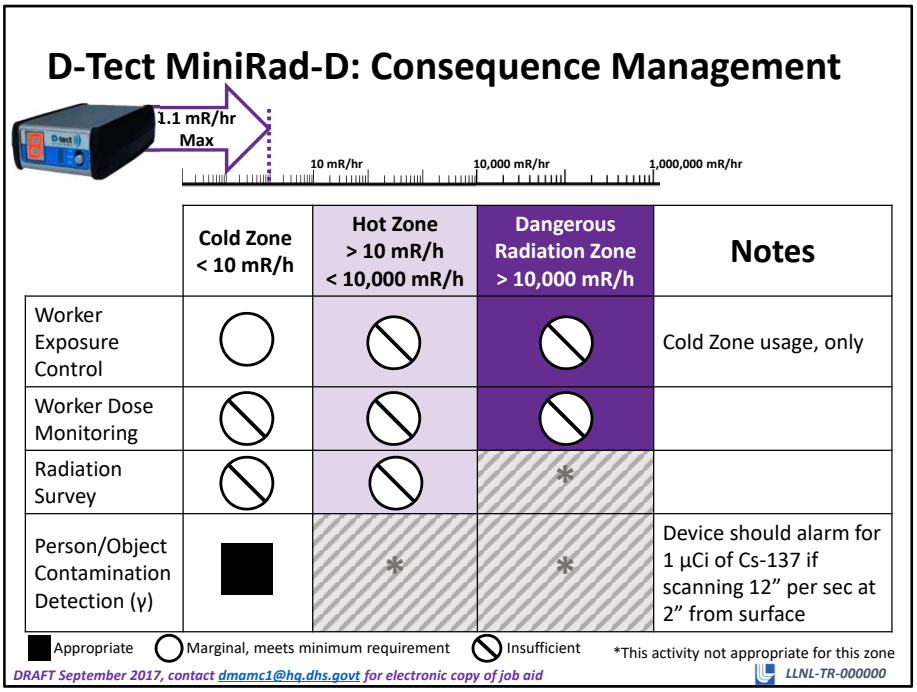

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Dangerous Radiation Zone: The NCRP defines a Dangerous Radiation Zone (DRZ) where exposure rate exceeds 10 R/h (10,000 mR/h), within which, actions taken should be restricted to time-sensitive, mission-critical activities, such as lifesaving.

Worker Exposure Control – For photon energies most likely to be encountered in an emergency, the capability to warn the user he/she was approaching or have entered the Hot Zone or the Dangerous Radiation Zone.
Worker Dose Monitoring – The capability to measure integrated exposure or dose and alarm when predetermined levels are exceeded.
Radiation Survey – Instruments that have the capability to display exposure or dose rate can be used to warn the approach to or establish the boundary of a radiation hazard zone or project accumulated dose.
Person/Object External Contamination Detection (γ) – The capability to determine if the contamination on a person or object exceeds predetermined criteria. For this mission, sensitivity is important. The device should be able to detect low levels of contamination on a person or object. In a large-scale event, initial screening levels 1 µCi of Cs-137 spot contamination are considered acceptable. Equipment that could effective 0.1 mR/h could also be used for higher contamination levels, but this would be considered marginal. Testing a Brookhaven National Laboratories, demonstrated that many PRDs could be used to detect 1 µCi of Cs-137 spot contamination at a distance of 2 inches from the surface of clothing, skin, or object and move it at a speed of 12 inches s^{-1}. The Job Aids of the tested equipment will list the appropriate survey height and speed useful for finding 1 µCi of Cs-137 as demonstrated through testing. Untested equipment will list presumed survey height and speed based on how closely the equipment matches tested equipment's sensitivity and specifications.

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D-Tect MiniRad-D: Consequence Management

Operation

- Move ON button to either the Speaker (Spk) or Vibrate (Vib) position.
- The instrument self-tests for about 30 sec., it will either beep or vibrate to let you know that the self-test is complete.
- Numbers 1-9 will appear when in a radiation field. The higher the number, the higher the radiation field.
- When you see the number 9, you are above 1.1 mrem/h. It cannot accurately display/determine what the dose rate is in your area. Back out of the area until the unit shows a number 8 (between 0.6 and 1.1 mrem/h).

Alarm Level	mrem/hr
1	0.035
2	0.040
3	0.055
4	0.065
5	0.100
6	0.200
7	0.350
8	0.600
9	>1.100

WARNING: This unit has limited use in worker exposure control.

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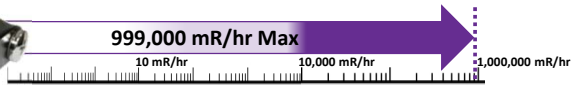
Polimaster PM1703MO-1: Consequence Management



	Cold Zone < 10 mR/h	Hot Zone > 10 mR/h < 10,000 mR/h	Dangerous Radiation Zone > 10,000 mR/h	Notes
Worker Exposure Control	■	■	■	Consider setting Dose and Dose Rate alarms (see back)
Worker Dose Monitoring	■	■	■	**Zero Dose** (see back) or **Record instrument dose** before beginning and at end of operation
Radiation Survey	■	■	*	
Person/Object Contamination Detection (γ)	■	*	*	Device should alarm for 1 µCi of Cs-137 if scanning 12" per sec at 2" from surface

■ Appropriate ◯ Marginal, meets minimum requirement ⊘ Insufficient

*This activity not appropriate for this zone

DRAFT September 2017, contact dmamc1@hq.dhs.govt for electronic copy of job aid

LLNL-TR-000000

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Cold Zone: This is the area outside of the Hot Zone. There may be some contamination and elevated radiation in this area, but it is below the levels indicated for controlled access. e.g. a Hot Line. For a large incident, the Cold Zone may include areas where protective actions are in place, such as agricultural embargo. There may also be a response agency defined Warm Zone as a transition area between Hot and Cold Zones.
Hot Zone: The NCRP* identifies the Hot Zone boundary by exposure rate or surface contamination levels, > 10 mR/h.
Dangerous Radiation Zone: The NCRP defines a Dangerous Radiation Zone (DRZ) where exposure rate exceeds 10 R/h (10,000 mR/h), within which, actions taken should be restricted to time-sensitive, mission-critical activities, such as lifesaving.

Worker Exposure Control – For photon energies most likely to be encountered in an emergency, the capability to warn the user he/she was approaching or have entered the Hot Zone or the Dangerous Radiation Zone.
Worker Dose Monitoring – The capability to measure integrated exposure or dose and alarm when predetermined levels are exceeded.
Radiation Survey – Instruments that have the capability to display exposure or dose rate can be used to warn the approach to or establish the boundary of a radiation hazard zone or project accumulated dose.
Person/Object External Contamination Detection (γ) – The capability to determine if the contamination on a person or object exceeds predetermined criteria. For this mission, sensitivity is important. The device should be able to detect low levels of contamination on a person or object. In a large-scale event, initial screening levels 1 µCi of Cs-137 spot contamination are considered acceptable. Equipment that could effective 0.1 mR/h could also be used for higher contamination levels, but this would be considered marginal. Testing a Brookhaven National Laboratories, demonstrated that many PRDs could be used to detect 1 µCi of Cs-137 spot contamination at a distance of 2 inches from the surface of clothing, skin, or object and move it at a speed of 12 inches s^{-1}. The Job Aids of the tested equipment will list the appropriate survey height and speed useful for finding 1 µCi of Cs-137 as demonstrated through testing. Untested equipment will list presumed survey height and speed based on how closely the equipment matches tested equipment's sensitivity and specifications.

*National Council on Radiation Protection and Measurement. (2011), "Responding to a Radiological or Nuclear Terrorism Incident: A Guide for Decision Makers". Report No. 165, ISBN 978-0-9823843-3-6, December 31, 2010.

Polimaster PM1703MO-1: Consequence Management

To Read Dose

- Press and release the Mode button twice. Your accumulated dose will display for about 10 seconds. The screen will then default to the Dose Rate mode/screen.

Clearing the accumulated Dose Reading

- Turning the unit off resets the Dose reading. To turn the instrument off, press and hold the LIGHT button for 6-7 seconds until the LCD screen displays the flashing "OFF" message.

NOTE: Record Dose reading before clearing the accumulated dose.

Dose Alarm Set Point

- The instrument has one Dose alarm, this is usually set for an accumulated dose of 10R. May be adjusted as instructed above.

Dose Rate Alarm Set Points

- This instrument has 2 pre-set Dose Rate alarm set points.
  - Set point one is usually set at 30 uR/h
  - Set point two is usually set at 3 mR/h
- These set points may be changed using the Polimaster app on either an android or apple phone using Bluetooth, or using an IR reader.
- Only change the low level dose rate alarm if you do not plan to use the instrument for PRND contraband detections or the consequence mission of contamination monitoring.

Recommended Settings[1]	High Level	Low Level
Dose	NA*	4.5 R
Dose Rate	10 R/h	10 mR/h

** This setting not available for this model*

DRAFT September 2017, contact dmamc1@hq.dhs.govt for electronic copy of job aid

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Exposure Rate Alarms:

- Low Level 10 mR/h (0.01 R/h) is used to identify the ***hot line*** (ASTM), ***outer perimeter*** , or 0.01 R/h boundary of the Hot Zone, or Low Radiation Zone
- High level 10 R/h represents the boundary to the Dangerous Radiation Zone or Dangerous Fallout Zone

Total Exposure Alarms:

- The 4.5 R low level alarm is **~90% of the 5 rem** standard dose limit for **non-emergency** activities (OSHA, NRC, and DOE). 90% was the chosen alarm level to provide opportunity for the responder to leave the exposure area without exceeding the 5 rem limit. Even in emergency situations, exceeding the 5 rem guideline should only be done when critical, time sensitive missions are required and all appropriate actions are taken to reduce dose.
- The 50 R high level alarm is from the National Council of Radiation Protection and Measurement Report # 165 which states: "When the cumulative absorbed dose to an emergency responder reaches 50 rad (0.5 Gy), a decision be made on whether or not to withdraw the emergency responder from the hot zone. NCRP considers the 50 rad (0.5 Gy) cumulative absorbed dose a decision dose, not a dose limit."

References:

- ASTM E2601-15, Standard Practice for Radiological Emergency Response, http://www.astm.org/cgi-bin/resolver.cgi?E2601, ASTM International, West Conshohocken, PA, 2008, www.astm.org
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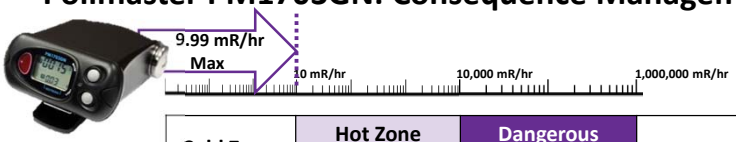
- CRCPD Publication 06-6, Handbook for Responding to a Radiological Dispersal Device: First Responders Guide – The First 12 Hours, Conference of Radiation Control Program Directors, September 2006, www.crcpd.org
- 29 CFR Part 1910.1096 (Ionizing Radiation) for OSHA's occupational limit. Under the OSHA Ionizing Radiation standard, the annual occupational limit for whole body radiation exposure for adults (age ≥18 years) is 5 rem (50 mSv)

Polimaster PM1703GN: Consequence Management



	Cold Zone < 10 mR/h	Hot Zone > 10 mR/h < 10,000 mR/h	Dangerous Radiation Zone > 10,000 mR/h	Notes
Worker Exposure Control	■	⊘	⊘	Cold Zone usage, only
Worker Dose Monitoring	⊘	⊘	⊘	
Radiation Survey	■	⊘	*	
Person/Object Contamination Detection (γ)	■	*	*	Device should alarm for 1 µCi of Cs-137 if scanning 12" per sec at 2" from surface

■ Appropriate ◯ Marginal, meets minimum requirement ⊘ Insufficient *This activity not appropriate for this zone

DRAFT September 2017, contact dmamc1@hq.dhs.govt for electronic copy of job aid LLNL-TR-000000

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Hot Zone: The NCRP* identifies the Hot Zone boundary by exposure rate or surface contamination levels, > 10 mR/h.
Dangerous Radiation Zone: The NCRP defines a Dangerous Radiation Zone (DRZ) where exposure rate exceeds 10 R/h (10,000 mR/h), within which, actions taken should be restricted to time-sensitive, mission-critical activities, such as lifesaving.

Worker Exposure Control – For photon energies most likely to be encountered in an emergency, the capability to warn the user he/she was approaching or have entered the Hot Zone or the Dangerous Radiation Zone.
Worker Dose Monitoring – The capability to measure integrated exposure or dose and alarm when predetermined levels are exceeded.
Radiation Survey – Instruments that have the capability to display exposure or dose rate can be used to warn the approach to or establish the boundary of a radiation hazard zone or project accumulated dose.
Person/Object External Contamination Detection (γ) – The capability to determine if the contamination on a person or object exceeds predetermined criteria. For this mission, sensitivity is important. The device should be able to detect low levels of contamination on a person or object. In a large-scale event, initial screening levels 1 µCi of Cs-137 spot contamination are considered acceptable. Equipment that could effective 0.1 mR/h could also be used for higher contamination levels, but this would be considered marginal. Testing a Brookhaven National Laboratories, demonstrated that many PRDs could be used to detect 1 µCi of Cs-137 spot contamination at a distance of 2 inches from the surface of clothing, skin, or object and move it at a speed of 12 inches s^{-1}. The Job Aids of the tested equipment will list the appropriate survey height and speed useful for finding 1 µCi of Cs-137 as demonstrated through testing. Untested equipment will list presumed survey height and speed based on how closely the equipment matches tested equipment's sensitivity and specifications.

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Polimaster PM1703GN: Consequence Management

Operation

- Push MODE button to turn unit ON
- When self-tests and background cal are complete, unit is ready for operation
- Push LIGHT button 5 seconds to turn OFF

Audio Alarm

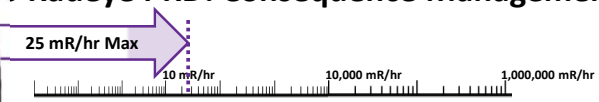
- Press and hold MODE
- Screen will display “CAL”, Continue to hold for approx. 4 seconds
- Screen will display "AUD" and either ON/OFF, release MODE
- Press the LIGHT button to toggle between On/OFF
- To exit back to dose screen, press MODE, or wait 6 seconds

Vibrate Alarm

- Press and hold the MODE
- Screen will display “CAL”, Continue to hold for approx. 4 seconds,
- Screen will display "AUD" and either ON/OFF, release MODE
- Press and release the mode again
- Screen will display "VIB" and either ON/OFF.
- Press the LIGHT button to toggle between On/OFF.
- To exit back to dose screen, press the MODE, or wait 6 seconds

DRAFT September 2017, contact dmamc1@hq.dhs.govt for electronic copy of job aid

Thermo Radeye PRD: Consequence Management



	Cold Zone < 10 mR/h	Hot Zone > 10 mR/h < 10,000 mR/h	Dangerous Radiation Zone > 10,000 mR/h	Notes
Worker Exposure Control	■	⊘	⊘	Cold Zone usage, only
Worker Dose Monitoring	■	⊘	⊘	
Radiation Survey	■	⊘	*	
Person/Object Contamination Detection (γ)	■	*	*	Device should alarm for 1 µCi of Cs-137 if scanning 12" per sec at 2" from surface

■ Appropriate ◯ Marginal, meets minimum requirement ⊘ Insufficient *This survey not conducted in this zone

DRAFT September 2017, contact dmamc1@hq.dhs.govt for an electronic copy of job aid

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Cold Zone: This is the area outside of the Hot Zone. There may be some contamination and elevated radiation in this area, but it is below the levels indicated for controlled access. e.g. a Hot Line. For a large incident, the Cold Zone may include areas where protective actions are in place, such as agricultural embargo. There may also be a response agency defined Warm Zone as a transition area between Hot and Cold Zones.
Hot Zone: The NCRP* identifies the Hot Zone boundary by exposure rate or surface contamination levels, > 10 mR/h.
Dangerous Radiation Zone: The NCRP defines a Dangerous Radiation Zone (DRZ) where exposure rate exceeds 10 R/h (10,000 mR/h), within which, actions taken should be restricted to time-sensitive, mission-critical activities, such as lifesaving.

Worker Exposure Control – For photon energies most likely to be encountered in an emergency, the capability to warn the user he/she was approaching or have entered the Hot Zone or the Dangerous Radiation Zone.
Worker Dose Monitoring – The capability to measure integrated exposure or dose and alarm when predetermined levels are exceeded.
Radiation Survey – Instruments that have the capability to display exposure or dose rate can be used to warn the approach to or establish the boundary of a radiation hazard zone or project accumulated dose.
Person/Object External Contamination Detection (γ) – The capability to determine if the contamination on a person or object exceeds predetermined criteria. For this mission, sensitivity is important. The device should be able to detect low levels of contamination on a person or object. In a large-scale event, initial screening levels 1 µCi of Cs-137 spot contamination are considered acceptable. Equipment that could effective 0.1 mR/h could also be used for higher contamination levels, but this would be considered marginal. Testing a Brookhaven National Laboratories, demonstrated that many PRDs could be used to detect 1 µCi of Cs-137 spot contamination at a distance of 2 inches from the surface of clothing, skin, or object and move it at a speed of 12 inches s^{-1}. The Job Aids of the tested equipment will list the appropriate survey height and speed useful for finding 1 µCi of Cs-137 as demonstrated through testing. Untested equipment will list presumed survey height and speed based on how closely the equipment matches tested equipment's sensitivity and specifications.

*National Council on Radiation Protection and Measurement. (2011), "Responding to a Radiological or Nuclear Terrorism Incident: A Guide for Decision Makers". Report No. 165, ISBN 978-0-9823843-3-6, December 31, 2010.

Thermo Radeye PRD: Consequence Management

Operation

- Push ON button (hold for 2–3 sec) to turn unit ON
- Self-tests, when CPS or dose rate screen appears, unit is ready for use
- Push MENU button for unit options, Use UP & DOWN arrows to scroll options, use RIGHT arrow to select option
- Push button on top of unit twice (rapidly) for FINDER mode
- Push MENU, select OFF, confirm YES to turn off unit

WARNING: Only change the low level dose rate alarm if you do not plan to use the instrument for PRND contraband detections or the consequence mission of contamination monitoring.

Setting Alarms

- The menu options "Alarm Cnt Rate", Alarm Dose Rate, Alarm Dose, and Alarm Level allow the alarm thresholds to be modified. Changing the value is effected by pressing the left (Change) button if the corresponding "Alarm" is selected.
- To increment the number, press the up/down arrow keys. To go on to the next digit or to quit the edit mode, menu use right/left arrow keys

Recommended Settings[1]	High Level	Low Level
Dose	NA[1]	4.5 R
Dose Rate	NA[1]	10 mR/h

1. *This model for use in Cold Zone, only. The maximum measurable dose rate is 25 mR/hr*

DRAFT September 2017, contact dmamc1@hq.dhs.govt for an electronic copy of job aid

Emergency workers operate under reference values and guidelines rather than regulatory dose limits while working in an emergency exposure situation. Default alarm set points are provided that correlate to national and international reference values and guidelines for emergency response. It is expected that many agencies will have alternate alarm set points defined by internal policy and the Job Aids are being provided in an editable PowerPoint format so that they may change the Job Aids to match their policies.

Exposure Rate Alarms:

- Low Level 10 mR/h (0.01 R/h) is used to identify the ***hot line*** (ASTM), ***outer perimeter*** , or 0.01 R/h boundary of the Hot Zone, or Low Radiation Zone

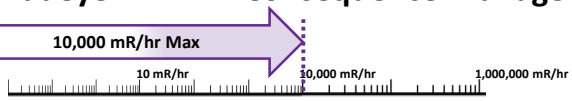
Total Exposure Alarms:

- The 4.5 R low level alarm is **~90% of the 5 rem** standard dose limit for **non-emergency** activities (OSHA, NRC, and DOE). 90% was the chosen alarm level to provide opportunity for the responder to leave the exposure area without exceeding the 5 rem limit. Even in emergency situations, exceeding the 5 rem guideline should only be done when critical, time sensitive missions are required and all appropriate actions are taken to reduce dose.

References:

- ASTM E2601-15, Standard Practice for Radiological Emergency Response, http://www.astm.org/cgi-bin/resolver.cgi?E2601, ASTM International, West Conshohocken, PA, 2008, www.astm.org
- Executive Office of the President Homeland Security Council Interagency Policy Coordination subcommittee for Preparedness and Response to Radiological and Nuclear Threats, Planning Guidance for Response to a Nuclear Detonation (June 2010). Office of Science and Technology Policy, available at www.ostp.gov
- CRCPD Publication 06-6, Handbook for Responding to a Radiological Dispersal Device: First Responders Guide – The First 12 Hours, Conference of Radiation Control Program Directors, September 2006, www.crcpd.org
- 29 CFR Part 1910.1096 (Ionizing Radiation) for OSHA's occupational limit. Under the OSHA Ionizing Radiation standard, the annual occupational limit for whole body radiation exposure for adults (age ≥18 years) is 5 rem (50 mSv)

Thermo Radeye PRD-ER: Consequence Management



	Cold Zone < 10 mR/h	Hot Zone > 10 mR/h < 10,000 mR/h	Dangerous Radiation Zone > 10,000 mR/h	Notes
Worker Exposure Control	■	■	⊘	Consider setting Dose and Dose Rate alarms (see back)
Worker Dose Monitoring	■	■	⊘	**Zero Dose** or **Record instrument dose** before beginning and at end of operation
Radiation Survey	■	■	*	
Person/Object Contamination Detection (γ)	■	*	*	Device should alarm for 1 µCi of Cs-137 if scanning 12" per sec at 2" from surface

■ Appropriate ◯ Marginal, meets minimum requirement ⊘ Insufficient *This activity not appropriate for this zone

DRAFT September 2017, contact dmamc1@hq.dhs.govt for an electronic copy of job aid *LLNL-TR-000000*

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Hot Zone: The NCRP* identifies the Hot Zone boundary by exposure rate or surface contamination levels, > 10 mR/h.
Dangerous Radiation Zone: The NCRP defines a Dangerous Radiation Zone (DRZ) where exposure rate exceeds 10 R/h (10,000 mR/h), within which, actions taken should be restricted to time-sensitive, mission-critical activities, such as lifesaving.

Worker Exposure Control – For photon energies most likely to be encountered in an emergency, the capability to warn the user he/she was approaching or have entered the Hot Zone or the Dangerous Radiation Zone.
Worker Dose Monitoring – The capability to measure integrated exposure or dose and alarm when predetermined levels are exceeded.
Radiation Survey – Instruments that have the capability to display exposure or dose rate can be used to warn the approach to or establish the boundary of a radiation hazard zone or project accumulated dose.
Person/Object External Contamination Detection (γ) – The capability to determine if the contamination on a person or object exceeds predetermined criteria. For this mission, sensitivity is important. The device should be able to detect low levels of contamination on a person or object. In a large-scale event, initial screening levels 1 µCi of Cs-137 spot contamination are considered acceptable. Equipment that could effective 0.1 mR/h could also be used for higher contamination levels, but this would be considered marginal. Testing a Brookhaven National Laboratories, demonstrated that many PRDs could be used to detect 1 µCi of Cs-137 spot contamination at a distance of 2 inches from the surface of clothing, skin, or object and move it at a speed of 12 inches s^{-1}. The Job Aids of the tested equipment will list the appropriate survey height and speed useful for finding 1 µCi of Cs-137 as demonstrated through testing. Untested equipment will list presumed survey height and speed based on how closely the equipment matches tested equipment's sensitivity and specifications.

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Thermo Radeye PRD-ER: Consequence Management

Alarm Indication

- Alarm 1: LED slowly blinking, 2-frequency alarm tone
- Alarm 2: LED quick blinking, continuous alarm tone
- NBR-Alarm: LED quick blinking, two frequency alarm tone
- Dose Alarm: LED constantly on, continuous alarm tone, vibrator slow

Display

- Pressing the up arrow/dose key shows current dose rate (on 1st click) and the accumulated dose on 2nd click.

Setting Alarms

- The menu options **Alarm Cnt Rate**, **Alarm Dose Rate**, **Alarm Dose**, and **Alarm Level** allow the alarm thresholds to be modified. Changing the value is effected by pressing the left (Change) button if the corresponding "Alarm" is selected.
- To increment the number, press the up/down arrow keys. To go on to the next digit or to quit the edit mode menu use right/left arrow keys. Press Exit key when done.

Recommended Settings	Alarm 2 (High)	Alarm 1 (Low)
Dose	50 R	4.5 R
Dose Rate	10 R/h[1]	10 mR/h

1. ***The maximum measurable dose rate of this model is 10,000 mR/hr***

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Exposure Rate Alarms:

- Low Level 10 mR/h (0.01 R/h) is used to identify the ***hot line*** (ASTM), ***outer perimeter*** , or 0.01 R/h boundary of the Hot Zone, or Low Radiation Zone
- High level 10 R/h represents the boundary to the Dangerous Radiation Zone or Dangerous Fallout Zone

Total Exposure Alarms:

- The 4.5 R low level alarm is **~90% of the 5 rem** standard dose limit for **non-emergency** activities (OSHA, NRC, and DOE). 90% was the chosen alarm level to provide opportunity for the responder to leave the exposure area without exceeding the 5 rem limit. Even in emergency situations, exceeding the 5 rem guideline should only be done when critical, time sensitive missions are required and all appropriate actions are taken to reduce dose.
- The 50 R high level alarm is from the National Council of Radiation Protection and Measurement Report # 165 which states: "When the cumulative absorbed dose to an emergency responder reaches 50 rad (0.5 Gy), a decision be made on whether or not to withdraw the emergency responder from the hot zone. NCRP considers the 50 rad (0.5 Gy) cumulative absorbed dose a decision dose, not a dose limit."

References:

- ASTM E2601-15, Standard Practice for Radiological Emergency Response, http://www.astm.org/cgi-bin/resolver.cgi?E2601, ASTM International, West Conshohocken, PA, 2008, www.astm.org
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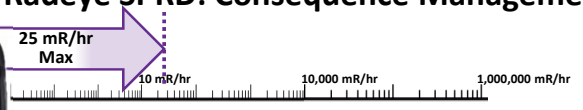
Thermo Radeye SPRD: Consequence Management



	Cold Zone < 10 mR/h	Hot Zone > 10 mR/h < 10,000 mR/h	Dangerous Radiation Zone > 10,000 mR/h	Notes
Worker Exposure Control	■	⊘	⊘	Consider setting Dose and Dose Rate alarms (see back)
Worker Dose Monitoring	■	⊘	⊘	**Zero Dose** or **Record instrument dose** before beginning and at end of operation
Radiation Survey	■	⊘	*	
Person/Object Contamination Detection (γ)	■	*	*	Device should alarm for 1 µCi of Cs-137 if scanning 12" per sec at 2" from surface

■ Appropriate ○ Marginal, meets minimum requirement ⊘ Insufficient *This activity not appropriate for this zone

DRAFT September 2017, contact dmamc1@hq.dhs.govt for an electronic copy of job aid LLNL-TR-000000

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Cold Zone: This is the area outside of the Hot Zone. There may be some contamination and elevated radiation in this area, but it is below the levels indicated for controlled access. e.g. a Hot Line. For a large incident, the Cold Zone may include areas where protective actions are in place, such as agricultural embargo. There may also be a response agency defined Warm Zone as a transition area between Hot and Cold Zones.
Hot Zone: The NCRP* identifies the Hot Zone boundary by exposure rate or surface contamination levels, > 10 mR/h.
Dangerous Radiation Zone: The NCRP defines a Dangerous Radiation Zone (DRZ) where exposure rate exceeds 10 R/h (10,000 mR/h), within which, actions taken should be restricted to time-sensitive, mission-critical activities, such as lifesaving.

Worker Exposure Control – For photon energies most likely to be encountered in an emergency, the capability to warn the user he/she was approaching or have entered the Hot Zone or the Dangerous Radiation Zone.
Worker Dose Monitoring – The capability to measure integrated exposure or dose and alarm when predetermined levels are exceeded.
Radiation Survey – Instruments that have the capability to display exposure or dose rate can be used to warn the approach to or establish the boundary of a radiation hazard zone or project accumulated dose.
Person/Object External Contamination Detection (γ) – The capability to determine if the contamination on a person or object exceeds predetermined criteria. For this mission, sensitivity is important. The device should be able to detect low levels of contamination on a person or object. In a large-scale event, initial screening levels 1 µCi of Cs-137 spot contamination are considered acceptable. Equipment that could effective 0.1 mR/h could also be used for higher contamination levels, but this would be considered marginal. Testing a Brookhaven National Laboratories, demonstrated that many PRDs could be used to detect 1 µCi of Cs-137 spot contamination at a distance of 2 inches from the surface of clothing, skin, or object and move it at a speed of 12 inches s^{-1}. The Job Aids of the tested equipment will list the appropriate survey height and speed useful for finding 1 µCi of Cs-137 as demonstrated through testing. Untested equipment will list presumed survey height and speed based on how closely the equipment matches tested equipment's sensitivity and specifications.

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Thermo Radeye SPRD: Consequence Management

Alarm Indication

- Alarm 1 Gamma: Red LED blinking, 2-frequency alarm tone
- Alarm 2 Gamma: Red LED blinking, continuous alarm tone
- NBR-alarm Gamma: Red LED blinking, sweeping alarm tone
- Dose Alarm Gamma: LED constantly on, continuous alarm tone

Display

- Pressing the up arrow/dose key shows the current gamma dose rate on 1st click and the accumulated gamma dose on 2nd click.
- The SPRD display may be switched to Cross-Mode to indicate dose rate with bar graph of cps value for more rapid finding of rad. sources.

Setting Alarms

- The menu options Count Rate G, Count Rate N, Dose Rate G and Alarm Dose G allow the alarm thresholds to be modified. Changing the value is effected by pressing the left (Change) button if the corresponding "Alarm" is selected.
- To increment the number, press the up/down arrow keys. To go on to the next digit or to quit the edit mode menu use right/left arrow keys. Press Exit key when done.

Recommended Settings	High Level	Low Level
Dose	N/A[1]	4.5 R
Dose Rate	10 mR/h[1]	Leave as is

1. ***The maximum measurable dose rate of this model is 25 mR/hr***

DRAFT September 2017, contact dmamc1@hq.dhs.govt for an electronic copy of job aid

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Exposure Rate Alarms:

- Low Level 10 mR/h (0.01 R/h) is used to identify the ***hot line*** (ASTM), ***outer perimeter*** , or 0.01 R/h boundary of the Hot Zone, or Low Radiation Zone

Total Exposure Alarms:

- The 4.5 R low level alarm is **~90% of the 5 rem** standard dose limit for **non-emergency** activities (OSHA, NRC, and DOE). 90% was the chosen alarm level to provide opportunity for the responder to leave the exposure area without exceeding the 5 rem limit. Even in emergency situations, exceeding the 5 rem guideline should only be done when critical, time sensitive missions are required and all appropriate actions are taken to reduce dose.

References:

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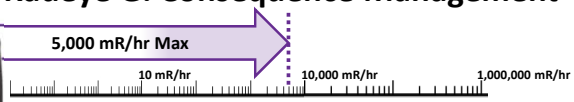
Thermo Radeye G: Consequence Management



	Cold Zone < 10 mR/h	Hot Zone > 10 mR/h < 10,000 mR/h	Dangerous Radiation Zone > 10,000 mR/h	Notes
Worker Exposure Control	■	◯	⊘	Consider setting Dose and Dose Rate alarms (see back)
Worker Dose Monitoring	■	◯	⊘	**Zero Dose** or **Record instrument dose** before beginning and at end of operation
Radiation Survey	■	◯	*	
Person/Object Contamination Detection (γ)	⊘	*	*	Device is NOT expected to alarm for 1 µCi of Cs-137 if scanning 12" per sec at 2" from surface

■ Appropriate ◯ Marginal, meets minimum requirement ⊘ Insufficient *This activity not appropriate for this zone

DRAFT September 2017, contact dmamc1@hq.dhs.govt for an electronic copy of job aid LLNL-TR-000000

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Hot Zone: The NCRP* identifies the Hot Zone boundary by exposure rate or surface contamination levels, > 10 mR/h.
Dangerous Radiation Zone: The NCRP defines a Dangerous Radiation Zone (DRZ) where exposure rate exceeds 10 R/h (10,000 mR/h), within which, actions taken should be restricted to time-sensitive, mission-critical activities, such as lifesaving.

Worker Exposure Control – For photon energies most likely to be encountered in an emergency, the capability to warn the user he/she was approaching or have entered the Hot Zone or the Dangerous Radiation Zone.
Worker Dose Monitoring – The capability to measure integrated exposure or dose and alarm when predetermined levels are exceeded.
Radiation Survey – Instruments that have the capability to display exposure or dose rate can be used to warn the approach to or establish the boundary of a radiation hazard zone or project accumulated dose.
Person/Object External Contamination Detection (γ) – The capability to determine if the contamination on a person or object exceeds predetermined criteria. For this mission, sensitivity is important. The device should be able to detect low levels of contamination on a person or object. In a large-scale event, initial screening levels 1 µCi of Cs-137 spot contamination are considered acceptable. Equipment that could effective 0.1 mR/h could also be used for higher contamination levels, but this would be considered marginal. Testing a Brookhaven National Laboratories, demonstrated that many PRDs could be used to detect 1 µCi of Cs-137 spot contamination at a distance of 2 inches from the surface of clothing, skin, or object and move it at a speed of 12 inches s^{-1}. The Job Aids of the tested equipment will list the appropriate survey height and speed useful for finding 1 µCi of Cs-137 as demonstrated through testing. Untested equipment will list presumed survey height and speed based on how closely the equipment matches tested equipment's sensitivity and specifications.

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Thermo Radeye G: Consequence Management

Alarm Indication

- Alarm 1: LED slowly blinking, 2-frequency alarm tone
- Alarm 2: LED quick blinking, continuous alarm tone
- Dose Alarm: LED constantly on, continuous alarm tone, vibrator slow

Display

- Pressing the up arrow/dose key shows current accumulated dose on 1st click and the dose rate on 2nd click.

Setting Alarms

- The menu options **Alarm Dose Rate** and **Alarm Dose** allow the alarm thresholds to be modified. Changing the value is effected by pressing the left (Change) button if the corresponding "Alarm" is selected.
- To increment the number, press the up/down arrow keys. To go on to the next digit or to quit the edit mode menu use right/left arrow keys

Recommended Settings[1]	High Level	Low Level
Dose	50 R	5 R
Dose Rate	5 R/h[1]	10 mR/h

1. *The maximum measurable dose rate of this model is 5,000 mR/hr*

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Exposure Rate Alarms:

- Low Level 10 mR/h (0.01 R/h) is used to identify the ***hot line*** (ASTM), ***outer perimeter***, or 0.01 R/h boundary of the Hot Zone or Low Radiation Zone
- High level 5 R/h alarm is the closest that this devise could get to the preferred 10 R/h represents the boundary to the Dangerous Radiation Zone or Dangerous Fallout Zone

Total Exposure Alarms:

- The 4.5 R low level alarm is **~90% of the 5 rem** standard dose limit for **non-emergency** activities (OSHA, NRC, and DOE). 90% was the chosen alarm level to provide opportunity for the responder to leave the exposure area without exceeding the 5 rem limit. Even in emergency situations, exceeding the 5 rem guideline should only be done when critical, time sensitive missions are required and all appropriate actions are taken to reduce dose.
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- It is expected that individual agencies may have different alarm set points and the Job Aids will be distributed in an editable format so they can be adjusted to match agency policies.

References:

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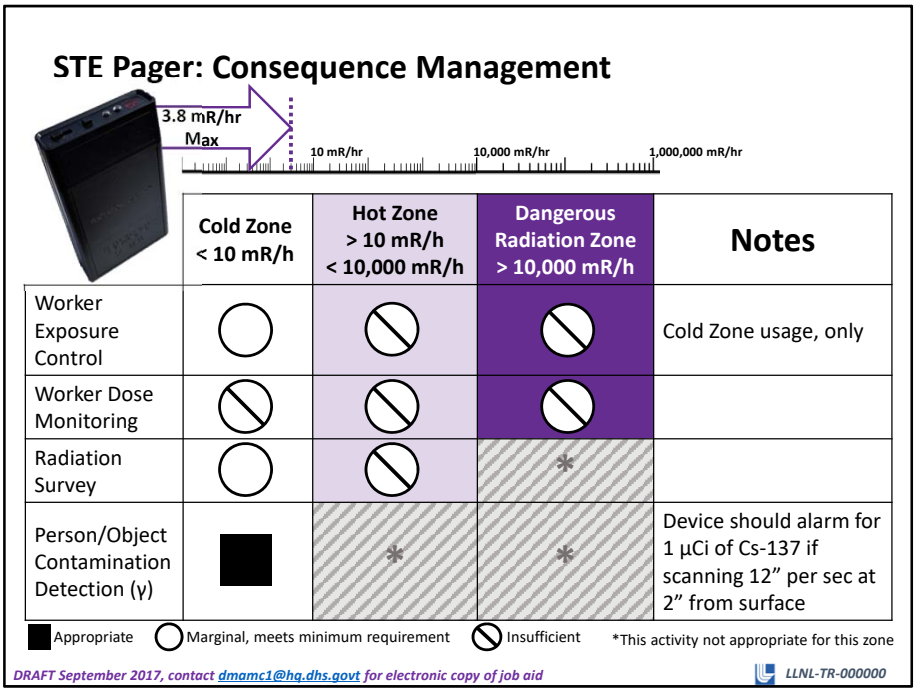

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STE Pager: Consequence Management

Operation

- Move the switch to either SPK or VIB, unit is ON. The unit self-tests for about 30 seconds, it will either beep or vibrate to indeicate the self-test is complete. The LED flashes yellow during the self-test, then turns green for OK.
- Numbers 1-9 will appear when in elevated radiation field. The higher the number, the higher the radiation field.
- When you see the number 9, you are at the maximum range of the instrument. It cannot measure the exposure rate in your area. Back out of the area until the unit shows a number 8

Alarms

- Press black button to silence alarm. If not alarming, pressing black button will check if unit is operating.

Alarm Level	mrem/hr
0	0.007
1	0.015
2	0.03
3	0.06
4	0.12
5	0.24
6	0.48
7	0.96
8	1.9
9	>3.8

WARNING: This unit has limited use in worker exposure control, **should be used in Cold Zones**, only.

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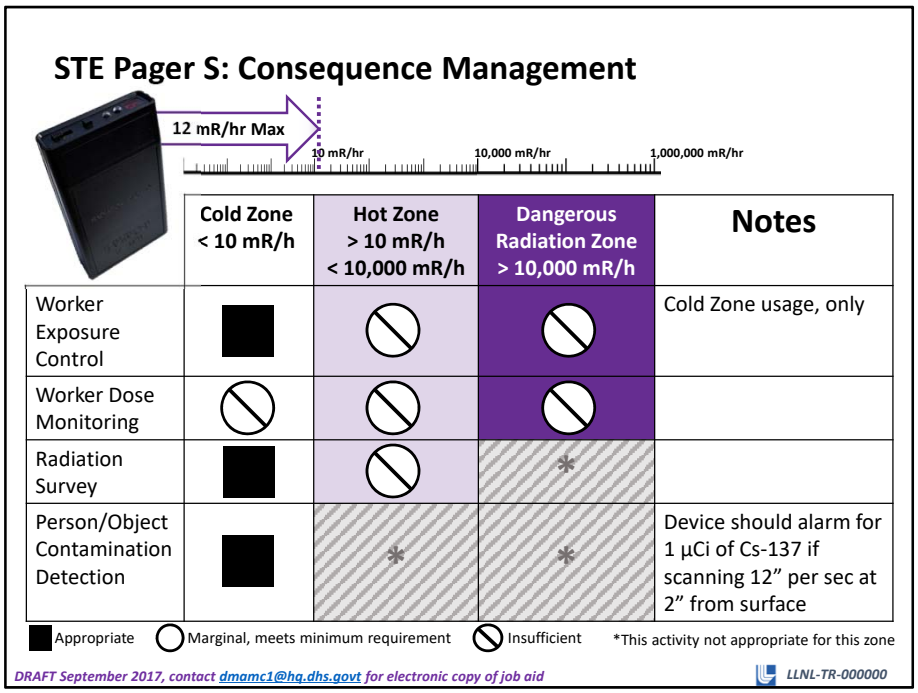

Lawrence Livermore National Laboratory developed this DRAFT Job Aid for the Department of Homeland Security's National Urban Science and Technology Laboratory "First Responder Use of Preventive Radiological/Nuclear Detection (PRND) Equipment During Consequence Management Operations" project. For more information, contact Benjamin Stevenson <Benjamin.Stevenson@hq.dhs.gov> or Brooke Buddemeier <buddemeier1@llnl.gov>

Cold Zone: This is the area outside of the Hot Zone. There may be some contamination and elevated radiation in this area, but it is below the levels indicated for controlled access. e.g. a Hot Line. For a large incident, the Cold Zone may include areas where protective actions are in place, such as agricultural embargo. There may also be a response agency defined Warm Zone as a transition area between Hot and Cold Zones.
Hot Zone: The NCRP* identifies the Hot Zone boundary by exposure rate or surface contamination levels, > 10 mR/h.
Dangerous Radiation Zone: The NCRP defines a Dangerous Radiation Zone (DRZ) where exposure rate exceeds 10 R/h (10,000 mR/h), within which, actions taken should be restricted to time-sensitive, mission-critical activities, such as lifesaving.

Worker Exposure Control – For photon energies most likely to be encountered in an emergency, the capability to warn the user he/she was approaching or have entered the Hot Zone or the Dangerous Radiation Zone.
Worker Dose Monitoring – The capability to measure integrated exposure or dose and alarm when predetermined levels are exceeded.
Radiation Survey – Instruments that have the capability to display exposure or dose rate can be used to warn the approach to or establish the boundary of a radiation hazard zone or project accumulated dose.
Person/Object External Contamination Detection (γ) – The capability to determine if the contamination on a person or object exceeds predetermined criteria. For this mission, sensitivity is important. The device should be able to detect low levels of contamination on a person or object. In a large-scale event, initial screening levels 1 µCi of Cs-137 spot contamination are considered acceptable. Equipment that could effective 0.1 mR/h could also be used for higher contamination levels, but this would be considered marginal. Testing a Brookhaven National Laboratories, demonstrated that many PRDs could be used to detect 1 µCi of Cs-137 spot contamination at a distance of 2 inches from the surface of clothing, skin, or object and move it at a speed of 12 inches s^{-1}. The Job Aids of the tested equipment will list the appropriate survey height and speed useful for finding 1 µCi of Cs-137 as demonstrated through testing. Untested equipment will list presumed survey height and speed based on how closely the equipment matches tested equipment's sensitivity and specifications.

*National Council on Radiation Protection and Measurement. (2011), "Responding to a Radiological or Nuclear Terrorism Incident: A Guide for Decision Makers". Report No. 165, ISBN 978-0-9823843-3-6, December 31, 2010.

STE Pager S: Consequence Management

Operation

- Move the switch to either SPK or VIB, unit is ON. The unit self-tests for about 30 seconds, it will either beep or vibrate to indicate the self-test is complete. The LED flashes yellow during the self-test, then turns green for OK
- Numbers 1-9 will appear when in elevated radiation field. The higher the number, the higher the radiation field.
- Gamma update: press update button to reset gamma bkgd when 9 is reached or entering area of lower bkgd. Maximum Gamma Range is 12mR/hr, with multiple resets.
- When you see the number 9, you are at the maximum range of the instrument. Back out of the area until the unit shows a number 8.

Alarms

- Press black button to silence alarm. If not alarming, pressing black button will check if unit is operating.

WARNING: This unit has limited use in worker exposure control, **should be used in Cold Zones**, only.

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