PURPOSE

To familiarize Operations-level personnel with the CANBERRA UltraRadiac™ Personal Radiation Detector (PRD).

To provide directives for daily operational checks to be performed by Operations-level personnel.

To provide action guidelines for use of the UltraRadiac™ PRD in the field.

REFERENCES

UltraRadiac Personal Radiation Detector™ – Users Manual, CANBERRA Industries, Inc., 2006

Radiological Incidents, Unit 77 Policy - Draft, SFD, 2009

Protective Action Recommendations For A Radiological Dispersal Event Including Improvised Nuclear Devices, WDOH, 2007

Planning Guidance For Response To A Nuclear Detonation, Homeland Security Council and Office of Science and Technology Policy, Executive Office of the President, 2009

Competencies For Operations-Level Responders Assigned Mission-Specific Responsibilities, Standard For Competence Of Responders To Hazardous Materials/Weapons Of Mass Destruction Incidents, NFPA 472 Chapter 6

Competencies For Responders Assigned Radiological Agent-Specific Tasks, Standard For Competence Of Responders To Hazardous Materials/Weapons Of Mass Destruction Incidents, NFPA 472 Annex D

DEFINITIONS

Dose The total amount of radiation received. Also called Accumulated Dose.

Dose Rate The average rate (in time) of radiation exposure; e.g., Roentgen per hour (R/hr). Also called Rate

Gamma One of the three types of natural radioactivity; unlike alpha and beta radiation, which are particles, gamma radiation is electromagnetic radiation (like X-rays or microwaves). Gamma rays are a most energetic and far-reaching form of electromagnetic radiation, with a very short wavelength

PRD Personal Radiation Detector

Rate The amount of radiation measured by the UltraRadiac™ every 2 seconds, then extrapolated to and displayed as units per hour

rem Roentgen equivalent man

Roentgen Unit of radiation exposure (R); directly proportional to **rem** which measures the biological danger of absorbed radiation

Stay Time How much time remains, at the current Dose Rate, before the High Dose Alarm is triggered. (If the Dose Rate goes up, remaining Stay Time will go down.)

GENERAL INFORMATION

The potential threat of a radiological terrorism incident requires that first responders be equipped with a radiation monitor designed to address the radiation hazards they may face. CANBERRA's UltraRadiac™ Personal Radiation Detector (PRD) is being assigned to all Operations-level apparatus as a small, rugged, simple-to-operate radiation monitor that measures and displays both the instantaneous radiation dose rate, and the total dose that is received. Alarms are annunciated by a flashing display and loud audible signal when set dose rate or total dose alarm levels are exceeded. These thresholds are pre-set by Services prior to distribution and are determined by the Hazardous Materials Response Guidelines. They are not programmable by Operations-level users.

There are two separate alarm levels for both dose rate and total absorbed dose. The first alarm (Low Level Alarm) is set at a level somewhat above natural background to alert personnel that abnormal radiation is present. The second alarm (High Level Alarm) is set at a higher level, indicating a significant hazard that requires immediate action. The PRD also has a "stay time" feature that shows personnel how much time (at the current dose rate) he/she can remain in place before the high dose alarm is reached.

All companies in Operations will be issued an UltraRadiac™ by the Services Division. Services will maintain spare units to back-up frontline units not passing the Daily Operations Check discussed below. Action guidelines for when and where to power on the PRD are discussed below.

Other specifications:

- Gamma detector only – will not detect alpha or beta radiation
- Detection range of 1 µR/hr – 500 R/hr (dose rate) and 0.1 µR to 999 R (total dose)
- Low Rate Alarm set at 100 µR/hr
- High Rate Alarm set at 1 R/hr
- Low Dose Alarm set at 1 R
- High Dose Alarm set at 5 R
- Unit has an initialization time of less than 5 seconds
- Four AAA 1.5V alkaline batteries will provide 150 hours of continuous monitoring

- Low battery indication is triggered when remaining battery life is approximately 10 hours

- Unit is immersible to 3 ft and can be technically decontaminated
- Unit is NOT intrinsically safe

BASIC FUNCTIONS

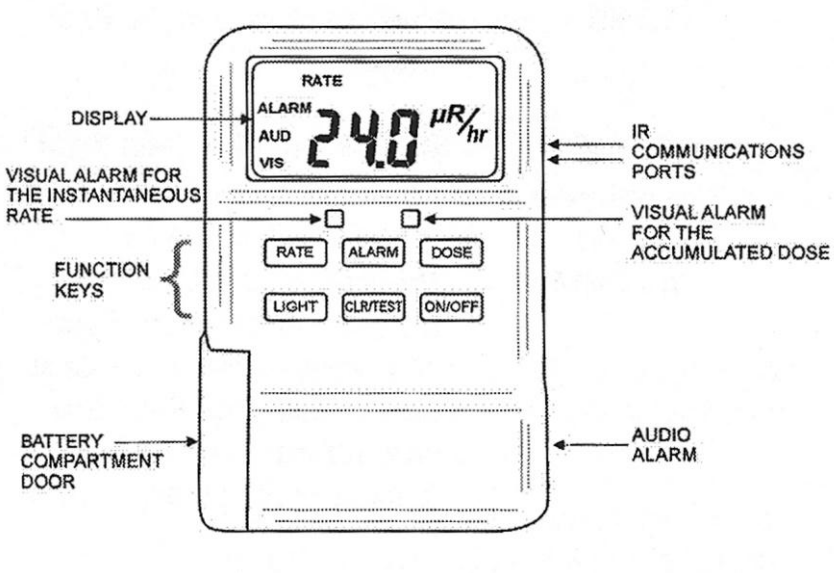


Figure 1 – The UltraRadiac™ Front Panel

The Function Keys

ON/OFF Press and hold to turn the unit on or off.

DOSE Press to change to the Dose Mode (default ON mode is RATE). Current accumulated dose is displayed in R.

RATE Press to change to Rate Mode from Dose Mode. Current Rate is displayed in R/hr.

ALARM Press to see the Stay Time, the number of minutes you can safely stay in the area at the current Dose Rate.

LIGHT Press to illuminate the display for about 5 seconds.

CLR/TEST In the Rate Mode, press and hold to enable the Display Test Sequence (see Daily Operational Check).

Battery Life Indicators

- If a blinking *b* is displayed, the unit has stopped functioning. Replace the batteries before the unit's next use.
- If a blinking *BAT* is seen in the top-left corner of the display, the unit's batteries have 10 hours or less of useful life. Replace the batteries as soon as possible.
- If the display is blank, the batteries are dead. Replace the batteries before the next use.

- In the Rate mode with the *BAT* indicator blinking, press the CLR/TEST key. A three-digit number indicating the approximate remaining battery life, in minutes, will be displayed.
- **NOTE: When replacing batteries at any time, be sure to turn the unit off first!**

DAILY OPERATIONAL CHECK

While periodic maintenance and calibration of the UltraRadiac™ PRD will be handled by Services, all Operations companies will perform Daily Operational Checks on the units assigned to them.

1. Check the calibration due date. If calibration is within 30 days of expiration, coordinate with Commissary for transfer of unit for re-calibration.

2. Perform a visual inspection. Remove dust, moisture, loose dirt from outside surfaces of the unit with a clean, soft cloth. If necessary, the unit may be cleaned with a mild solution of ordinary detergent and water, rinsed, and thoroughly dried.

3. Press and hold the ON/OFF key until the display appears, and release the key.
    - The Rate Mode should appear, with the word *RATE* shown at the top left of the screen (Figure 2).

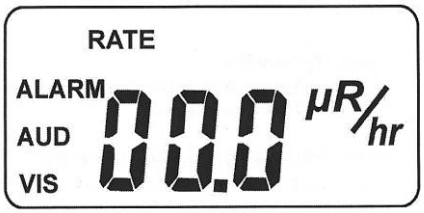


Figure 2 – The Rate Display

    - *AUD* and *VIS* indicate that the Audio and Visual alarms are both enabled.
    - The unit will start counting and displaying the instantaneous Rate. Naturally occurring background radiation will cause the unit to display a low reading.

- Press the DOSE key to switch to Dose Mode. The Dose Mode should appear, with the word *DOSE* shown at the top left of the screen (Figure 3)

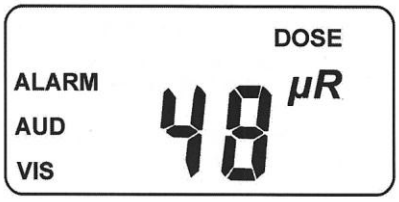


Figure 3 – The Dose Display

- Press the RATE key to switch to Rate Mode.

4. While in Rate Mode, press and hold the CLR/TEST key until you see the test display in Figure 4 (approximately 4 seconds), and release the key.

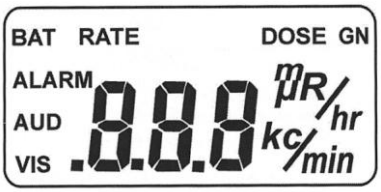


Figure 4 – The Test Display

- A set of numbers in the following order will appear. Check that all of the numbers are exactly as shown in Figure 5.

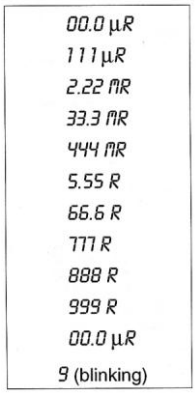


Figure 5 – Test Sequence

- At any time during the CLR/TEST sequence of numbers:
  - Press the RATE key – the audio alarm should sound and the Rate LED (left one below the display) should turn on.
  - Press the DOSE key – the audio alarm should sound and the Dose LED (right one below the display) should turn on.
  - Press the ALARM key – the audio alarm should sound and both LEDs should turn on.

- The blinking *9* indicates that the unit passed all self-tests. A blinking *0* indicates a failure; contact Services immediately to arrange replacement.

- Press the ***CLR/TEST*** key to return to Rate Mode (or wait about 10 seconds).

5. Press the ***LIGHT*** key; the display's backlight will turn on for about 5 seconds.

6. **IMPORTANT: Clear the accumulated dose each day at change of shift!** Press and hold ***DOSE*** and ***CLEAR/TEST***. The display will flash for a few seconds, then clear any accumulated dose. Return to the Rate Mode by pressing the ***RATE*** key.

7. Press and hold the ***ON/OFF*** key.
   - *OFF* will be displayed.
   - – – – will then be displayed. Release the ON/OFF key; the unit will power off.

ACTION GUIDELINES

NFPA 472, *"Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents"* was changed for 2008 to include new skill requirements for Operations-Level personnel. While basic core competencies were not changed, a new mission-specific menu of objectives has been added, including air monitoring and sampling, evidence preservation and sampling, and victim rescue and recovery. The new standard and its mission-specific competencies address what the fire service has already found to be true: Operations-level personnel will fill in where possible and do what must be done when Technicians are not available.

The UltraRadiac™ gives Operations-level personnel an additional tool to not only facilitate better recognition of radiological incidents, but to enhance Operations-level participation in monitoring radiological incidents, making the scene safer for both Operations- and Technician-level personnel. Operations-level first responders – the most likely to diagnose a radiological terrorist/WMD event – will need to provide initial information about the radiation characterization of the incident site, as well be able to determine for themselves safe routes of travel to victims or fires.

Any unexplained detonation shall be considered a potential terrorist event utilizing a radiological dispersal device. Place, time, occupancy, and other clues to the origin of an explosion will determine Operations-level approaches to the response. Obviously, a car fire on the freeway would be considered an explained event and not necessitate the use of the PRD; a car bomb in front of the Federal Building would be suspicious and require the use of the PRD when approaching the incident.

While on day-to-day business, leave the PRD stowed on the apparatus with power off.

Power on the PRD, clear any accumulated Dose, and deploy the units from the apparatus when:

- **Responding to unexplained detonations (assume RDD) or any other inexplicable circumstances: USE COMMON SENSE**

- **Responding to known HazMat incidents or to known hazard sites (for example hospitals, cancer-care units, industrial sites, universities, etc.)**
- **Elevated Threat Level (local/national)**
- **Directed by the Chief of the Department**

When the UltraRadiac™ is deployed, crews will employ a process known as the "Radiological Alarm Response Guide" to:

- **DETECT** elevated radiation levels
- **VERIFY** the radiation alarm
- **LOCALIZE** or narrow down the radioactive field or source material
- **MEASURE** the radiation level

Detect

Detection begins when any of the radiation alarms on the PRD are triggered. Average background radiation is 5 – 25 µR/hr. The Low Level Rate Alarm for all Operations-level units is set at 100 µR/hr. Note that this is still an exceedingly small amount of radiation: 100 times less than the rate at which Operations-level personnel will be directed to turn back (10 mR/hr), and 500,000 times less than the rate at which a stay time of an hour would result in minor biological effects (50 R). See Appendix I for an explanation of metric prefixes, and Appendix II for time/dose equivalents. A Low Level Rate Alarm indicates the abnormal presence of some radiation. Units should observe their surroundings (location, occupancy, event, anything that is out of place). Acknowledge the alarm and note the Rate reading.

Verify

Move in a direction that allows the UltraRadiac™ to fall below the Low Level Rate Alarm (100 µR/hr). Return to the original area and observe if the instrument goes back into alarm. A repeat measurement with the same or other instrument is a positive indication that there is a real increase in radiation. Further investigation will be required. Again consider your surroundings:

- Could there be a legal process for using a radioactive source (e.g. hospitals, labs, medical treatment centers)?
- Is it a high value target (e.g. event with large group of people or dignitaries, government building)?
- Is there anything out of place (e.g. large, unplacarded vehicles, unattended packages)?

A verified Low Level Rate Alarm (100 µR/hr) indicates an abnormal presence of radiation. If no legal explanation exists, contact the FAC via radio for a HAZRAD response (reduced HazMat radiation response) and verbalize the Rate readings and suspected threat in the initial report. Also request SPD to your location.

If initial readings send the PRD into High Rate Alarm (1 R/hr) immediately, contact the FAC via radio for a HAZMAT response (full Hazmat response) and provide the Rate readings and suspected threat in the initial report.

Localize

A verified alarm requires further investigation. Recall that the Low Alarm for the UltraRadiac™ is set at 100 μR/hr. Also recall that the SFD Operations-level safe general work Rate limit is determined to be 10 mR/hr, 100 times higher. Operations-level crews will have plenty of time in range to attempt to localize the source of the material before being required to turn back – this will be a great asset to the HazMat team when it arrives to perform mitigation efforts. Note that your primary use of the PRD is to further your tactical objectives (victim rescue, fire suppression, etc.) by determining safe routes of travel through a possible radiation field; NOT to become Technician-level identifiers or mitigators.

The UltraRadiac™ has a response time of about 2 seconds. By slowly sweeping the unit left to right, up and down, and around, pausing every few feet or so for 2 seconds, crews will be able to "hone in" on the source. Caution must be taken to give the unit time to catch up to your forward motion. Crews should attempt to use command boards or paper and pencil to keep records of their progress. Use as much detail as possible to map your immediate environs.

The result of the localization process is the approximate direction towards the radioactive material. In this fashion, "safe corridors" to victims can be mapped out, as well as providing valuable information about the point origin of the radioactivity, dissemination of the radioactivity, and contamination of the surrounding area. Remember that you can move forward toward the source in this fashion until you begin achieving Rates at 10 mR/hr. If this happens, return to a safe area (a Rate under 10 mR/hr).

Measure

As measurements are taken, describe the location in enough detail to be able to relocate the suspected source or general area.

- Take readings with the PRD positioned as close as possible to the suspected source. Note your distance from the suspected source (person, package, vehicle, building, object).
- Always remember to record the units of the reading (μR/hr, mR/hr, R/hr). This is very important for later reckoning of absorbed doses.
- If possible, and allowed by Rate guidelines, take a reading at the distance of one meter from the suspected source and record the results. Try to attain readings from more than one direction near the source.

Do not attempt to measure under the following circumstances:

- You achieve Rate readings of greater than 10 mR/hr at 10 feet away from the suspected source; consider your tactical objectives – if only in survey mode, turn back
- Any High Alarm is activated

- The Gamma Detector Overload message (– – –) appears on the screen
- Undetonated explosives are suspected
- Loose, spilled, or leaking material is observed.

If you are unable to measure due to above conditions, report the following to the HazMat team and retreat to a safe location:

- Highest Rate reading
- Approximate location where the reading was taken
- Approximate distance from the suspected source where the reading was taken
- Description of the suspected source, including markings, labels, dimensions, color.

Important Note: The "Turnback Rate" of 10 mR/hr applies to crews in survey operations. However, the new NFPA 472, *Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents*, allows for Operations-level personnel to work in the Hot Zone to achieve important tactical objectives. Crews now have the PRD to further guide them toward completion of those objectives. While crews are directed to not go beyond the 10 mR/hr threshold while surveying, life-safety operations and other high-value mission-specific objectives can still be performed at higher rates with commonsense precautions. OSHA specifies the following exposure limits for emergency workers in radiation fields:

- 5 rem any work
- 10 rem to protect property
- 25 rem to protect life (exceeded voluntarily with knowledge of risks)

Crews are directed to use the Dose function of the PRD to monitor their accumulated dose while operating in fields beyond the High Rate Alarm and performing high-value tactical objectives. Members must remain physically proximal to each other for the PRD's readings to apply to the entire crew. Crews must at all times practice the ALARA Principle (As Low As Reasonably Achievable) and at no time should crews exceed the OSHA exposure limits for life safety actions (25 rem). By monitoring with the PRD for lower-rate pathways through a radiation field, crews can significantly and positively influence the outcomes of a significant event.

CONCLUSION

The CANBERRA UltraRadiac™ is just one more tool to aid Operations-level companies while safely performing their duties at emergency scenes. As with any other operation, no one tool can replace common sense and judiciousness. Understanding the abilities and the limitations of the PRD will help companies make wise decisions when dealing with a radiological event. Performing the daily operations check and regularly practicing with the UltraRadiac™ will foster familiarity with the instrument, familiarity that will be of great use should companies be called upon to assist the HazMat team when responding to an actual incident.

ACKNOWLEDGEMENTS

Technical Writer . . . . . Firefighter Karl Zapf (SFD HazMat Team; Engine 10)

Technical Review and Editing . . . . . .Captain Geoff Wall (SFD HazMatTeam; Ladder 1)

Technical Review . . . . . Assistant Chief A. D. Vickery, Risk Management
Lt. Luis Batayola (SFD HazMat Team; Ladder 1)
Firefighter Grady Poole (SFD HazMat Team; Ladder 1)
Firefighter Ryan Nash (SFD HazMat Team; Engine 10)

APPENDICES

Appendix I Metric Prefixes

A metric prefix is a modifier on the root word to tell us the unit of measure. For example, milligram (mg) means we are counting in steps of one one-thousandth of a gram and microgram (µg) means millionths of a gram. Note that numbers we generally deal with in the macroscopic world reside in range 10^{-6} to 10^{6}. Units used in this training guide can be viewed as:

Prefix	Symbol	Numerical Multiplier	Exponential
kilo	**k**	**1,000**	**10^{3}**
No prefix		**1**	**10^{0}**
centi	**c**	**0.01**	**10^{-2}**
milli	**m**	**0.001**	**10^{-3}**
micro	**µ**	**0.000001**	**10^{-6}**

Appendix II DOSE RATES AND ABSORBED DOSE AS A FUNCTION OF TIME

TIME/DOSE EQUIVALENTS

TIME UNTIL INDICATED DOSE LEVEL IS RECEIVED (in HOURS unless otherwise specified)

		MODERATE DOSE						*HIGH DOSE*		
DOSE RATE	**Limit To Protect Valuable Property**	**15 R**	**20 R**	**25 R**	**30 R**	**40 R**	**50 R**	**75 R**	**100 R**	**300 R**
	10 R			**Limit For Life-Safety Rescue**	**2% Increased Chance Of Cancer**		**Temporary Blood Changes**	**Radiation Sickness Likely**		**LD_{50} Dose Limit (EPA)**
100 µR/hr	100,000	150,000	200,000	250,000	300,000	400,000	500,000	750,000	1,000,000	3,000,000
10 mR/hr	1,000	1,500	2,000	2,500	3,000	4,000	5,000	7,500	10,000	30,000
50 mR/hr	200	300	400	500	600	800	1,000	1,500	2,000	6,000
100 mR/hr	100	150	200	250	300	400	500	750	1,000	3,000
500 mR/hr	20	30	40	50	60	80	100	150	200	600
1 R/hr	10	15	20	25	30	40	50	75	100	300
5 R/hr	2	3	4	5	6	8	10	15	20	60
10 R/hr	1	1.5	2	2.5	3	4	5	7	10	30
50 R/hr	12 min	18 min	24 min	30 min	36 min	48 min	1	1.5	2	6
100 R/hr	6 min	9 min	12 min	15 min	18 min	24 min	30 min	45 min	1	3
150 R/hr	4 min	6 min	8 min	10 min	12 min	16 min	20 min	30 min	40 min	2
200 R/hr	3 min	4 min	6 min	7 min	9 min	12 min	15 min	22 min	30 min	1.5

Example: The CANBERRA UltraRadiac™ measures a radiation dose-rate of 100 µR/hr (Low Dose-Rate Alarm). Personnel could work in that radiation field, at that rate, for 250,000 hours before absorbing the OSHA-determined dose limit for life-safety rescue (25 R). That is equivalent to working 28½ years, 24 hours a day, without break. Likewise, personnel can work 25 hours at the High Dose-Rate Alarm rate of 1 R/hr before reaching that limit.

Appendix III

AVERAGE ANNUAL ABSORBED DOSE FROM NATURALLY OCCURRING AND MAN-MADE SOURCES

To put radiation exposure in perspective, consider some sources that everyone is exposed to, year after year:

Smoke detectors	0.008	mrem (8 µrem)
LCD wristwatch	0.06	mrem (60 µrem)
Porcelain crowns/dentures	0.07	mrem (70 µrem)
Jet plane travel	0.5	mrem per hour in air (Seattle to NY ~ 3.4 mrem)
Computer screen/TV	1	mrem
X-ray (extremities)	1	mrem
X-ray (chest)	6	mrem
Stone, brick, concrete	7	mrem
Cosmic space radiation	26	mrem
Food and water	40	mrem
Terrestrial radiation (Continental US)	63	mrem
X-ray (pelvis)	65	mrem
Naturally-occurring radon	200	mrem (0.2 rem)
X-ray (Upper GI)	245	mrem (0.245 rem)
Cigarettes (1 pack per day)	1300	mrem (1.3 rem)

The average annual dose per person from just environmental sources is about 360 mrem per year, 81% of which comes from natural sources of radiation. It is not, however, uncommon for persons to receive far more than that in a given year (largely due to medical procedures such as X-rays and CAT scans).

The human body largely has mechanisms for absorbing this dose with minimal risk of long-term negative effects.

Appendix IV

CANBERRA ULTRARADIAC DAILY CHECK SHEET

All Operations companies will perform Daily Operational Checks on the UltraRadiac™ PRD units assigned to them.

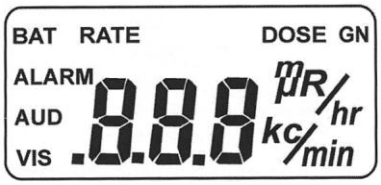
1. Check the calibration due date. If calibration is within 30 days of expiration, coordinate with Commissary for transfer of unit for re-calibration.

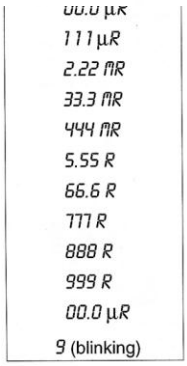
2. Perform a visual inspection. Remove dust, moisture, loose dirt from outside surfaces of the unit with a clean, soft cloth.

3. Press and hold the ON/OFF key until the display appears, and release the key.
   - The Rate Mode should appear, with the word *RATE* shown at the top left of the screen.
   - The unit will start counting and displaying the instantaneous Rate.

4. Press the DOSE key to switch to Dose Mode.
   - The Dose Mode should appear, with the word *DOSE* shown at the top left of the screen.
   - Press the RATE key to switch to Rate Mode.

5. While in Rate Mode, press and hold the CLR/TEST key until you see the test display (approximately four seconds), and release the key.
   - A set of numbers in order will appear. Check that all of the numbers are exactly as shown





   - At any time during the CLR/TEST sequence of numbers:
     - Press the RATE key – the audio alarm should sound and the Rate LED (left one below the display) should turn on.
     - Press the DOSE key – the audio alarm should sound and the Dose LED (right one below the display) should turn on.
     - Press the ALARM key – the audio alarm should sound and <u>both</u> LEDs should turn on.
   - A blinking *9* indicates that the unit passed all self-tests. A blinking *0* indicates a failure; contact Services immediately to arrange replacement.

6. Press the LIGHT key; the display's backlight will turn on for about 5 seconds.

7. **<u>IMPORTANT</u>: <u>CLEAR ACCUMULATED DOSE EACH DAY AT CHANGE OF SHIFT</u>!** Press and hold DOSE + CLEAR/TEST. The display will flash for a few seconds, then clear any accumulated dose. Return to the Rate Mode by pressing the RATE key.

8. Press and hold the ON/OFF key.
   - – – – will then be displayed. Release the ON/OFF key; the unit will power off.

When To Use It:

- **Responding to unexplained detonations (assume RDD) or any other inexplicable circumstances: USE COMMON SENSE**
- **Responding to known HazMat incidents or to known hazard sites (hospitals, cancer-care units, industrial sites, universities, etc.)**
- **Elevated Threat Level (local/national)**
- **Directed by the Chief of the Department**

Operational Reminders:

- **Power on the PRD and clear any accumulated Dose every day.**
- Crews are directed to not go beyond the 10 mR/hr threshold while surveying.
- Operations and other high-value mission-specific objectives can still be performed at higher rates with commonsense precautions. OSHA specifies the following lifetime exposure limits for emergency workers in radiation fields:
    - 5 rem any work
    - 10 rem to protect property
    - 25 rem to protect life (exceed voluntarily with knowledge of risks)
- Crews must at all times practice the ALARA Principle (As Low As Reasonably Achievable) and at no time should crews exceed the OSHA exposure limits for life safety actions (25 rem).