Rad 100™

NUCLEAR RADIATION MONITOR

Operating Manual

IMI
International Medcom, Inc

Rad 100™

Personal Radiation Detector

Operation Manual

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1 Introduction

The Rad 100 is a health and safety instrument that measures alpha, beta, gamma, and X-ray radiation. Its applications include:

- Monitoring possible radiation exposure while working with radionuclides
- Ensuring compliance with regulatory standards
- Checking for leakage from X-ray machines and other sources
- Screening for environmental contamination or environmental sources of radioactivity
- Connecting to a computer or data logger to record and tabulate your data

How the Rad 100 Detects Radiation

The Rad 100 uses a Geiger-Mueller tube to detect radiation. The Geiger tube generates a pulse of electrical current each time radiation passes through the tube and causes ionization. Each pulse is electronically detected and registers as a count. The Rad 100 displays the counts in the mode you choose: microsieverts per hour (μSv/hr), counts (CPM), or total counts. If conventional units (mR/hr) is preferred you can easily convert units displayed in the Utility Menu.

The count or dose rate displayed by the Rad 100 updates every 3 seconds and fluctuates due to the random nature of radioactivity. Use the Total mode feature on the instrument to get a highly accurate, unfluctuating reading by taking a measurement for a longer timed period. For more information, see “Operating in Total/Timer Mode” in Chapter 3.

Precautions

To keep the Rad 100 in good condition, handle it with care and observe the following precautions:

- Do not contaminate the Rad 100 by touching it to radioactive surfaces or materials.
- Do not leave the Rad 100 in temperatures over 122° F (50° C) or in direct sunlight for extended periods of time.
- Do not get the Rad 100 wet. Water can damage the circuitry and the coating of the mica surface of the Geiger tube.
- Do not put the Rad 100 in a microwave oven. It cannot measure microwaves, and you may damage it or the oven.
- If you expect to not use the Rad 100 for longer than a few months, remove the battery to avoid damage from battery corrosion.
- Change the battery when the battery indicator appears on the display.

2 Features

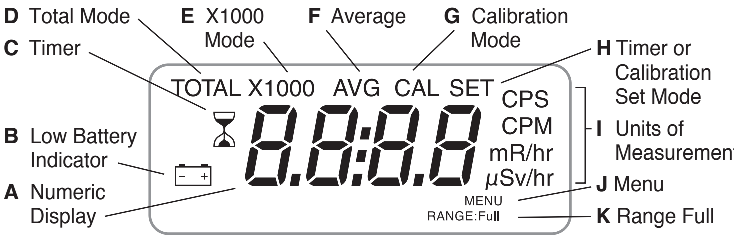
The Rad 100 measures alpha, beta, gamma, and X-radiation. This chapter briefly describes the Rad 100's functions. For more information on how to use the Rad 100, see Chapter 3, "Operation."

The instrument counts ionizing events and displays the results on the liquid crystal display (**LCD**) (**4**). You control which unit of measurement is shown by using the Mode switch.

When the Rad 100 is operating, the red count light **(1)** flashes each time a count (an ionizing event) is detected.

The Display

Several indicators on the LCD show information about the mode setting, the current function, and the battery condition.



- The **numeric display** (**A**) shows the current radiation level in the unit specified by the mode switch setting.
- A small **battery** (**B**) appears to the left of the numeric display to indicate low battery voltage.
- An **hourglass** (**C**) appears during a timed count.
- **TOTAL** (**D**) appears when the Rad 100 is in Total/Timer mode.
- **X1000** (**E**) appears when the radiation level is high. Multiply reading by 1,000 when this symbol is present.
- **AVG** (**F**) appears when the Rad 100 is showing the average reading for a timed count.
- **CAL** (**G**) appears while you are calibrating the Rad 100.
- **SET** (**H**) appears when you are setting the Timer, the calibration factor, or working in the Utility Menu (the numeric display shows the setting being adjusted instead of the current radiation level).
- The current **unit of measurement** (**I**)—**CPM, CPS, mR/hr,** or **µSv/hr**—is displayed to the right of the numeric display.
- **MENU** (**J**) appears when you are in the Utility Menu.
- **RANGE:Full** (**K**) appears when the radiation level goes beyond the range that can be displayed.

The Switches

The Rad 100 has two switches on the front and three buttons on the end panel. Each switch has three settings, which are described below.

Mode Switch (5)

Dose Rate. The numeric display shows the current radiation level in the selected unit of measurement. In SI units it shows the current radiation level in microsieverts per hour, from .000 to 1100. In conventional units, it shows milliroentgens per hour from .000 to 110.

Count Rate. The display shows the current radiation level in counts per minute from 0 to 350,000. When **X1000** is shown, multiply the numeric reading by 1,000 to get the complete reading.

Total/Timer. The display shows the accumulated total of counts starting when the switch is turned to this position, from 0 to 9,999,000. When **X1000** is shown, multiply the numeric reading by 1,000 to get the complete reading.

On/Off/Audio Switch (6)

Audio. The Rad 100 is on, and it makes a clicking sound for each radiation event detected.

On. The Rad 100 is operating, but audio is off.

Off. The Rad 100 is not operating.

+, –, and SET Buttons (7)

These buttons are used for setting the timer. They are also used for calibration and for using the Utility Menu. For more information, see “Taking a Timed Count,” “The Utility Menu” in Chapter 3 and “Calibration” in Chapter 5.

The Detector

The Rad 100 uses a Geiger tube to detect radiation. Alpha radiation does not penetrate most solid materials, so this Geiger tube has a thin disk of mica, which alpha radiation can penetrate, on its end. The screened opening at the top of the Rad 100 is called the **alpha window (8)**. It allows alpha and low-energy beta and gamma radiation to penetrate the mica end of the tube.

CAUTION: The mica end surface of the Geiger tube can be broken by direct impact. Be careful not to let anything penetrate the screen.

The Input/Output Ports

There are two ports on the left side of the Rad 100.

The **cal/probe input port** (**2**) is used for calibrating electronically using a pulse generator or an external IMI probe. For more information, see “Calibrating Electronically” in Chapter 5.

The **output port** (**3**) below the calibration input port allows you to interface the Rad 100 to GeigerLink™, a USB interface for collecting, displaying and sharing radiation data. This can also be used to connect to a computer, data logger, earphones, or other device using a 3.5 mm stereo plug. For more information, see “Interfacing to an External Device” in Chapter 3.

3 Operation

The guidelines in this chapter describe how to use the Rad 100.

Units of Measurement

The Rad 100 is designed both for users of SI units (microsieverts per hour and counts per minute) and for users of conventional units (milliroentgens per hour and counts per minute). The default is microsieverts per hour and counts per minute. To switch between units of measurement, use the Utility Menu. See "The Utility Menu" in this chapter.

Starting the Rad 100

Be sure that a standard 9-volt alkaline battery is installed in the battery compartment in the lower rear of the Rad 100.

***Note**: When installing the battery, place the battery wires along the side of the battery and not under it.*

To start the Rad 100, set the top switch to the mode you want, and set the bottom switch to **On** or **Audio**. The Rad 100 then does a brief system check, displaying all the indicators and numbers.

After the system check, the radiation level is displayed in the selected mode. Ninety seconds after you start the Rad 100, a short beep indicates that enough information has been collected to ensure statistical validity.

When using the Rad 100, always be sure there is no obstruction between the detector window and the source you are surveying or monitoring.

Operating in the Dose and Count Rate Modes

When the mode switch is set to **Dose Rate** or **Count Rate**, the numeric display is updated every three seconds. At low count rates, changes in the radiation level displayed can take up to 90 seconds to stabilize. See "Operating Ranges and Response Times" in this chapter for more information.

Count Rate (CPM) and timed total counts are the most direct methods of measurement; Dose Rate (μSv/hr or mR/hr) measurements are calculated using a conversion factor optimized for Cesium-137, so this mode is less accurate for other radionuclides unless you have calibrated the instrument for a specific radionuclide using an appropriate source. It is more appropriate to measure alpha and beta activity using Count Rate rather than using Dose Rate. Conversion for alpha and beta emitters is calculated differently, and the Rad 100's Dose Rate reading may not be accurate.

The most immediate indicators of the radiation level are the LCD and the audio beep. It takes three seconds before an increase is shown on the numeric display in Dose Rate mode.

Operating in Total/Timer Mode

When the mode switch is set to Total/Timer, the Rad 100 starts totaling the counts it registers, and the numeric display is updated every second.

Taking a Timed Count

A timed total count is useful for determining the average counts per minute over a period of time. The number of counts detected by the Rad 100 varies from minute to minute due to the random nature of radioactivity. When a count is taken over a longer period, the average count per minute is more accurate, and any small increase is more significant.

Taking an average allows you to detect low-level contamination or differences in background radiation due to altitude or soil mineral content, and can be useful for educational purposes. For example, if one 10-minute average is one count higher than another 10-minute average, the increase may be due to normal variation. But over 12 hours, a one count increase over the 12-hour background average is statistically significant.

The Rad 100 can give you a total count for a timed period of from one minute to 40 hours. Follow these steps:

1. With the Rad 100 operating, set the Mode switch to **Total/Timer**. The display shows **TOTAL**.
2. Press the Set button twice in quick succession. The display shows **SET**, the hourglass, and the most recent timing period used. The first time you use the timer, the setting is 24:00, which means 24 hours.

3. Use the + and – buttons to set the timing period. The timed period can be for 1 to 10 minutes in one-minute increments, for 10 minutes to 2 hours in ten-minute increments, or for 2 to 40 hours in one-hour increments.
4. Press the Set button again to start the timed count. The Rad 100 beeps three times and starts counting. The hourglass indicator flashes during the timed period.

   During the counting period, if you want to see how much time remains, press and hold down the Set button. The display counts down in hours and minutes to zero. For example, if the display says 00:21, 21 minutes remain.
5. At the end of the timed period, the Rad 100 beeps three times, and repeats the beeping several times. The number displayed is the total count.
6. To display the average count and dose rates for the timed period, press and hold the Set button. The display alternates between the average count rate and the average dose rate every 3 seconds, and shows **AVG** above the numeric display.
7. Press the Set button twice to return to normal operation.

After you start a timed count, the timer mode is active in the background even when the Mode switch is set to **Dose Rate** or **Count Rate**. For example, during and after the timed period, you can switch back and forth between **Total/Timer** and **Dose Rate**; when the timed period is over, the total is displayed whenever you switch back to **Total/Timer**. The hourglass indicator is shown on the display in any mode setting; it is blinking while the timer is totaling counts.

Taking a Total Count

The timer can take timed counts of up to 40 hours. In certain situations, you may want to take a total count without the timer; for example, taking a count for longer than 40 hours. Follow these steps:

1. Place the Rad 100 in the location where you plan to take the count.
2. Note the time.
3. Immediately when you note the time, set the mode switch to **Total/Timer**.

4. At the end of the time period, note the time and the total on the numeric display.
5. Subtract the starting time from the ending time to determine the exact number of minutes in the timing period.
6. To get the average count, divide the total reading by the number of minutes in the timing period.

Operating Ranges and Response Times

In some modes, when radiation levels increase over certain preset levels, the Rad 100 uses autoranging, automatically changing to the X1000 scale. Whenever **X1000** is shown above the numeric display, multiply the displayed reading by 1000 to determine the radiation level. The following table shows the radiation levels the Rad 100 measures in each mode and how they are displayed.

Mode	Regular Range	x1000 Range
µSv/hr	.000–1100	N/A
mR/hr	.000–110	N/A
CPM	0–9999	10,000–350,000 (displayed as 10.00–350 with x1000 indicator)
CPS	0–3500	N/A
Total/Timer	0–9999	10,000–9,999,000 (displayed as 10.00–9999 with x1000 indicator)

Maximum Level

When the maximum level for the current mode is reached, the Rad 100 beeps for three seconds, pauses for three seconds, and repeats that pattern. The display shows **RANGE:Full.** The beeping pattern and the Range Full icon continue until the level decreases or the Rad 100 is turned off.

Display Update and Response Time

In Total/Timer mode, the numeric display is updated each second. In the dose and count rate modes, the numeric display is updated every three seconds. When the radiation level is less than 1,000 CPM, the reading in the dose and count rate modes is based on the radiation detected in the immediately previous 90 seconds. In order to give a quicker response to changes, when the radiation level exceeds 1,000 CPM in any 90-second period, the reading is based on the previous 6 seconds, and when it exceeds 6,000 CPM, the reading is based on the previous 3 seconds, as shown in the following table. This automatic change in response time is called auto-averaging.

Radiation Level	**Basis for Reading (after first 90 seconds)**
<1000 CPM or <8.3 µSv/hr or <.83 mR/hr (<17 CPS)	90 seconds
1000–6000 CPM or 8.3–50 µSv/hr or .83–5 mR/hr (17–100 CPS)	6 seconds
>6000 CPM or >50 µSv/hr or >5 mR/hr (>100 CPS)	3 seconds

Note: *You can set the response time to 3 seconds at all radiation levels using the Utility Menu; see "The Utility Menu" in this chapter.*

The Utility Menu

The Utility Menu allows you to change the default settings for several operating parameters. When a setting is changed, it remains in effect after the Rad 100 is turned off and until you change it again.

- To activate the Utility Menu, hold down the **+** button on the end panel while you turn on the Rad 100. The word **MENU** appears at the bottom right of the numeric display, and the display shows **1** for menu option 1.
- To scroll through the menu, push the plus (+) and minus (–) buttons.
- To select an option, push the **Set** button.
- Once an option is selected, use the + and – buttons to scroll among the settings.
- After you choose the setting you want, select option 0 to exit the Utility Menu.

The options are:

0 **Resume normal operation**.

1 **Auto Averaging.** **on** (the default) selects Auto averaging; **oFF** selects 3-second (fast response) averaging at all radiation levels.

2 **Units of measurement**. **CPM µSv/hr** (the default) selects counts per minute and microsieverts per hour; **CPM mR/hr** selects counts per minute and milliroentgens per hour; **CPS µSv/hr** selects counts per second and microsieverts per hour.

3 **Cal 100 Reset.** Automatically resets the calibration factor to 100.

4, 5, 6 Reserved for future options.

7 **Cal Factor Adjust.** Displays the current calibration factor, which you can then adjust to the new factor you want. See "Calibration" in Chapter 5.

8 **Factory Default Reset.** Automatically resets items 1, 2, and 3 to Auto averaging, CPM and µSv/hr, and a Calibration Factor of 100.

9 **Revision #.** Displays the firmware version number.

Interfacing to an External Device

The lower output jack on the left side of the Rad 100 is a dual miniature jack that provides an audible click for use with a headset, or a data output that can be used to drive external devices. You can use it to record the counts on a computer, data logger, or accumulating counter. Use a 3.5 mm stereo plug to access this port.

The outputs provide a positive pulse (9 volt peak, 1 kOhm impedance) each time the Geiger tube detects a count. At the ring of the plug, the pulse is approximately 1 millisecond wide and is well suited for chart recorders and audio inputs. The tip signal is approximately 80 microseconds wide and is suitable for high-speed counting and RS-232 and USB adaptors.

Computer cables for USB or serial ports and accompanying software is available from IMI.

For 4.5V logic compatible output, externally connect a 1 kOhm resistor from the output to ground. A standard stereo or mono headphone can be plugged directly into the jack. For some types of headphones, external volume control may be needed.

GeigerLink by IMI, *GeigerGraph* by Mineralab and other third party data collection and sharing solutions are available for use with the Rad 100. Visit IMI at http://medcom.com for more information.

4 Common Procedures

The following sections give guidelines for several commonly-used procedures. With any procedure, the user must determine the suitability of the instrument or procedure for that application.

Establishing the Background Count

Normal background radiation levels vary at different locations, according to altitude and other factors, such as types of minerals in the ground. Levels vary at different distances from the ground, and may differ even in different areas of the same room. To accurately interpret the readings you get on the Rad 100, it is a good idea to establish the normal background radiation level for each area you plan to monitor. You can do this with a timed count. Use the following steps to get a ten-minute average.

1. With the Rad 100 operating, set the Mode switch to **Total/Timer**.
2. Press the Set button twice in quick succession.
3. The display shows the current timer period and **SET**. Unless you have previously changed it, the display reads 24:00, which means 24 hours. Use the + and – buttons to change the timer period to ten minutes.
4. Press the Set button on the end panel. The Rad 100 beeps three times and starts counting.

   During the timed count, if you want to see how much of the ten minutes remains, hold down the Set button. The display counts down from ten minutes to zero. For example, if the display says 00:03, seven minutes have elapsed and three minutes remain.
5. At the end of the ten minutes, the Rad 100 beeps three times, and repeats the beeping several times. Note the total reading.
6. To find the average count and dose rates, hold down the Set button.

A ten-minute average is moderately accurate. You can repeat it several times to find how close the averages are. To establish a more accurate average, take a one-hour timed count. In some locations, you may want to take a longer count (for example, 12 hours). If you need to determine whether there is contamination, take averages in several locations and compare the averages.

For more information on using the timer, see “Taking a Timed Count” in Chapter 3.

Environmental Area Monitoring

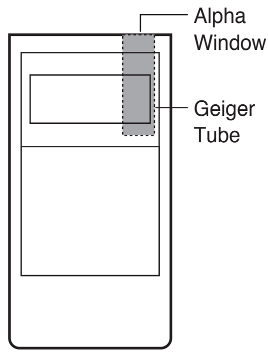
You can keep the Rad 100 in Dose Rate or Count Rate mode whenever you want to monitor the ambient radiation, and look at it from time to time to check for elevated readings.

If you suspect an increase in ambient radiation, use the timer to take a ten-minute count, and compare the average to your average background count. If you suspect an increase that is too small to detect with a short timed reading, you can take a longer count (for example 6, 12, or 24 hours).

Checking an Object

To check an object, place the Rad 100 next to it with the end window facing and near the object; otherwise you may miss alpha and low-level beta radiation. To determine if an object is slightly radioactive, place the Rad 100 next to it and take a timed count over an appropriate period of time.

When not using the end window, hold the Rad 100 so that the side wall of the tube is as close as possible to the object. The best position is with the top right corner of the back of the Rad 100 closest to the object



Position of Geiger Tube

To measure as much as possible of the radioactivity of an object, place the Rad 100 as close as you can without touching the object. The radiation level for gamma radiation from a localized source decreases according to the inverse square law. If you move to twice the distance from the object, the radiation drops by a factor of four.

CAUTION: Never touch the Rad 100 to an object that may be contaminated. You may contaminate the instrument. A contaminated instrument will not be accepted for repair or servicing.

5 Maintenance

The Rad 100 should be handled with care and can be calibrated as necessary to comply with regulations. Use the following guidelines to maintain the Rad 100 properly.

Calibration

The Rad 100's readings typically remain stable for many years of use. Specific industries, such as diagnostic laboratories, radiography, and public safety, operate under standards or regulations that require routine calibrations. In most regulated environments, an annual calibration meets these standards. Some standards require more frequent calibrations, and some also require the occasional use of a check source to make sure the instrument is working properly. For a recommended laboratory for instrument calibration, see the International Medcom, Inc. website at medcom.com. Check-sources are available from various licensed suppliers. Any radioactive source should be handled with caution and shielded properly during storage.

The standard radionuclide for calibration is Cesium-137. To calibrate to another radionuclide, use a calibrated source for that radionuclide or determine the appropriate conversion factor referenced to Cs-137. A certified test range should be used. Depending on the facility, calibrations are typically done at about two-thirds of the maximum reading, or 660 µSv/hr (66 mR/hr). Some labs can do a three-point calibration check at, for example, 250, 500, and 660 µSv/hr (25, 50, and 66 mR/hr). Calibration should not be done at levels below 10 µSv/hr (1mR/hr) or above 900 µSv/hr (90 mR/hr).

If no source is available, and the Geiger tube is functioning normally, an electronic calibration can be performed using a calibrated pulse generator. This confirms that the instrument is counting accurately, but does not confirm the Geiger tube sensitivity.

Calibrating Using a Source

Most certified calibration laboratories utilize robotics to minimize or eliminate radiation exposure to the calibration personnel. The Rad 100's calibration procedure is designed to further minimize exposure.

Before you calibrate the Rad 100, make sure the distance between the Rad 100 and the source is correct to produce the appropriate dose rate. Follow these steps:

1. Start with the Rad 100 turned off and the Mode switch set to **Dose Rate**.
2. Hold down the – button on the end panel while you turn the **On/Off/Audi**o switch to **On**. (Don't use the **Audio** setting.)

   The display shows **CAL**, and the Rad 100 counts down for 15 seconds, beeping each second. This delay gives you a chance to move out of the field and then expose the source. At the end of the 15 seconds, the Rad 100 beeps several times.
3. The Rad 100 collects data for 90 seconds, beeping as it does so, with **CAL** and the hourglass indicator flashing. At the end of the 90 seconds, it beeps several times. The display shows **CAL** and **SET**. You can now seal or close the source.
4. Press the + and – buttons to adjust the reading to what it should be. When the reading is correct, press the Set button. The new calibration factor is automatically calculated from the adjustment you make.
5. The new calibration factor is displayed for several seconds, then the Rad 100 beeps and resumes regular operation.

The calibration factor is set to 100 (percent) at the factory. If you change the reading, for example, to 20% higher than the factory reading, the new calibration factor would be 120. The current calibration factor is displayed during the system check when the Rad 100 is first turned on.

Calibrating Electronically

You can calibrate the Rad 100 electronically using a pulse or function generator. Electronic calibration requires a cable with a 2.5 mm plug, with the tip carrying the signal. Follow these steps:

1. Set the signal height amplitude to 3.3 volts (positive pulse).
2. Plug the cable into the upper jack.

3. Start with the Rad 100 turned off and the Mode switch set to **Dose Rate**. Hold down the – button on the end panel while you turn the On/Off/Audio switch to **On**. (Don't use the **Audio** setting.)

   The display shows **CAL**, and the Rad 100 counts down for 15 seconds, chirping each second. At the end of the 15 seconds, the Rad 100 beeps several times.

4. The Rad 100 collects data for 90 seconds, beeping as it does so, with **CAL** and the hourglass indicator flashing. At the end of the 90 seconds, it beeps several times. The display shows **CAL** and **SET**.

5. Use the following table to check the Rad 100's accuracy. The table shows appropriate pulse generator count rates to calibrate for Cs-137. If the accuracy is not within desired limits, follow step 6. Note that the Rad 100 automatically compensates for lost counts due to GM tube dead time. Thus, the display reading in CPM mode does not equal the input frequency. You can display uncompensated counts in CPM mode by continuously holding down the – (minus) button; the reading now corresponds to the input frequency.

Pulse Generator Input		Display			
Hz	Pulse/min	CPM	μSv/hr	mR/hr	CPS
162.97	9778	12,000	100	10	200
318.88	19133	24,000	200	20	400
748.50	44910	60,000	500	50	1,000
1128.67	67720	96,000	800	80	1,600
1358.70	81522	120,000	1,000	100	2,000

6. Press the + and – buttons to adjust the reading to what it should be. When the reading is correct, press the Set button. The new calibration factor is automatically calculated from the adjustment you make.

7. The new calibration factor is displayed for several seconds, then the Rad 100 beeps and resumes regular operation.

Troubleshooting and Service

The Rad 100 is a highly reliable instrument. If it does not seem to be working properly, look through the following chart to see if you can identify the problem.

Problem	Possible Cause	What to Check
Display is blank	Battery: dead, missing, or poor connection	Install and firmly connect a new 9-volt alkaline battery
Display works, but no counts are registered	Damaged Geiger tube	If the mica surface of the tube has visible breaks or wrinkles, it needs to be replaced
Reading is high, but another instrument has a normal reading in the same location	Contamination	Scan the Rad 100 with another instrument; clean the instrument with a damp cloth and mild detergent
	Moisture	The circuit board may be wet; dry the instrument in a warm dry place; if it still has a problem, it requires factory service
	Photosensitivity	Remove from direct sunlight and ultraviolet sources; if the high count drops, the mica coating on the Geiger tube may be coming off and the tube needs to be replaced
	Continuous discharge	The Geiger tube needs to be replaced
	Electromagnetic interference	Move the instrument away from sources of extremely high-energy non-ionizing radiation, e.g., electro-magnetic or microwave

If the Rad 100 requires servicing, please contact your distributor or International Medcom, Inc. for instructions on where to ship the instrument.

Contact IMI at 707-823-0336 or at customercare@medcom.com.

Do not attempt to repair the Rad 100; it contains no user-serviceable parts and you could void your warranty.

CAUTION: Do not send a contaminated instrument for repair under any circumstances. Contact IMI for support.

6 Basics of Radiation and Its Measurement

This chapter briefly tells what radiation is and how it is measured. This information is provided for users who are not already familiar with the subject. It is helpful in understanding how the Rad 100 works and in interpreting your readings.

Ionizing Radiation

Ionizing radiation is radiation that changes the structure of individual atoms by ionizing them. The ions produced in turn ionize more atoms. Substances that produce ionizing radiation are called radioactive.

Radioactivity is a natural phenomenon. Nuclear reactions take place continuously on the sun and all other stars. The emitted radiation travels through space, and a small fraction reaches the Earth. Natural sources of ionizing radiation also exist in the ground. The most common of these are uranium, radium, thorium and their decay products.

Ionizing radiation detected by the Rad 100 can be categorized into four types:

X-rays are usually man-made radiation produced by bombarding a metallic target with electrons at a high speed in a vacuum. X-rays are electromagnetic radiation of the same nature as light waves and radio waves, but at extremely short wavelength, less than 0.1 billionth of a centimeter. They are also called photons. The energy of X-rays is millions of times greater than that of light and radio waves. Because of this high energy level, X-rays penetrate a variety of materials, including body tissue.

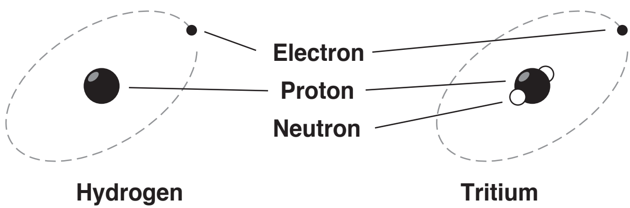
Gamma rays occur in nature and are almost identical to X-rays, but generally have a shorter wavelength than X-rays. Gamma rays are very penetrating; thick lead shielding is generally required to stop them.

Beta radiation. A beta particle consists of an electron emitted from an atom. It has mass so it generally doesn't penetrate matter as deeply as gamma and X-rays.

Alpha radiation. An alpha particle consists of two protons and two neutrons, the same as the nucleus of a helium atom. It generally can travel no more than 1 to 3 inches in air before stopping, and can be stopped by a piece of paper.

When an atom emits an alpha or beta particle or a gamma ray, it becomes a different type of atom. Radioactive substances may go through several stages of decay before they change into a stable, or non-radioactive, form.

An element may have several forms, or isotopes. A radioactive form of an element is called a radioisotope or radionuclide. Each radionuclide has a half-life, which is the time required for half of a quantity of the material to decay.



A hydrogen atom has one electron and one proton. The most common isotope has no neutrons and is stable.

Tritium is a radioactive isotope of hydrogen. It has two neutrons in its nucleus.

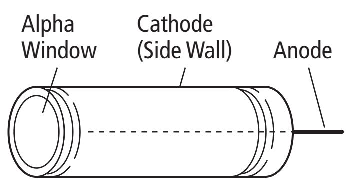
The chart on the following page shows the complete decay chain for Uranium 238, which ends with a stable isotope of lead. Each radionuclide decays to become other elements (referred to as daughters or progeny). For example U-238 becomes Th-234, which becomes Pa-234, etc. Notice that the half-life of the radionuclides in the chain range from 164 microseconds to 4.5 billion years.

Isotope	Emits	Half-life	Product	
U-238	alpha	4.5 billion years	Th-234	Thorium
Th-234	beta	24.1 days	Pa-234	Proactinium
Pa-234	beta	1.17 minutes	U-234	Uranium
U-234	alpha	250,000 years	Th-230	Thorium
Th-230	alpha	80,000 years	Ra-226	Radium
Ra-226	alpha	1,602 years	Rn-222	Radon
Rn-222	alpha	3.8 days	Po-218	Polonium
Po-218	alpha	3 minutes	Pb-214	Lead
Pb-214	beta	26.8 minutes	Bi-214	Bismuth
Bi-214	beta	19.7 minutes	Po-214	Polonium
Po-214	alpha	164 microseconds	Pb-210	Lead
Pb-210	beta	21 years	Bi-210	Bismuth
Bi-210	beta	5 days	Po-210	Polonium
Po-210	alpha	138 days	Pb-206	Lead

Measuring Radiation

Alpha, beta, gamma, and X-rays ionize material they strike or pass through. The amount of radiation is generally determined by measuring the resulting ionization.

The Geiger tube used in the Rad 100 consists of an anode (positive electrode) positioned in the center of a tubular cathode (negative electrode) filled with a mixture of argon, neon, and either chlorine or bromine gases. The cathode is a thin-walled metallic cylinder sealed at each end with an insulating disk to contain the gas. The anode is a wire that extends into the cylinder. A high voltage is applied to the electrodes to create an electrical field within the chamber. When radiation passes through the chamber and ionizes the gas, it generates a pulse of current. The Rad 100 electronically processes these pulses to display the radiation level.



Radiation Measurement Units

Several different units are used to measure radiation, exposure to radiation, and dosage.

A **roentgen** is the amount of X-radiation or gamma radiation that produces one electrostatic unit of charge in one cc of dry air at 0° C and 760 mm of mercury atmospheric pressure. The Rad 100 displays readings in milliroentgens per hour (mR/hr). A milliroentgen is one one-thousandth of a roentgen.

A **rad** is the unit of exposure to ionizing radiation equal to an energy of 100 ergs per gram of irradiated material. This is approximately equal to 1.07 roentgen.

A **rem** is the dosage received from exposure to a rad. It is the number of rads multiplied by the quality factor of the particular source of radiation. The rem and millirem (one one-thousandth of a rem) are the most commonly-used measurement units of radiation dose in the U.S. One rem is generally considered to equal one rad.

A **sievert** is the standard international measurement of dose. One sievert is equivalent to one hundred rems. A microsievert (μSv) is one millionth of a sievert.

A **curie** is the amount of radioactive material that decays at the rate of 37 billion disintegrations per second, approximately the decay rate of one gram of radium. Microcuries (millionths of a curie) and picocuries (trillionths of a curie) are also often used as units of measurement.

A **becquerel** (Bq) is equivalent to one disintegration per second.

Higher Than Normal Readings

Due to the random nature of radioactivity, the Rad 100 reading varies from minute to minute.

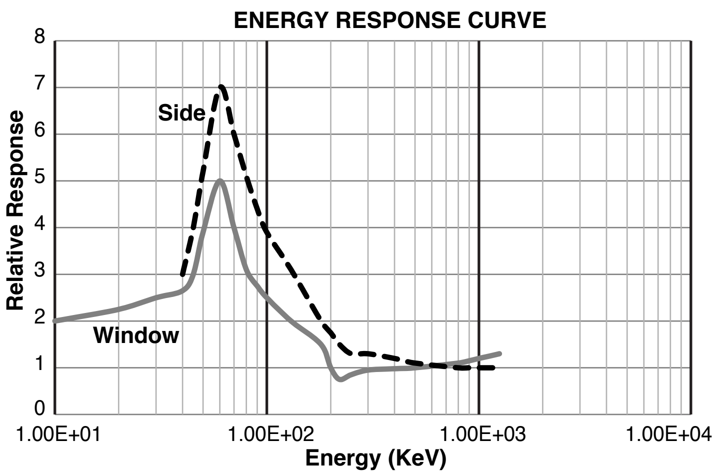
Normal radiation levels in different locations can vary greatly due to soil composition, altitude, and other factors. For example, normal background at 10,000 feet might be double that at sea level. On an airplane, the radiation at 35,000 to 40,000 feet may be as much as 30 to 50 times the normal level on the ground.

Granite counter tops and other natural sources of radiation can affect your readings. Once you get accustomed to what can be normally expected in various situations, it becomes relatively easy to see activity that is outside the range of what is normal. If you have questions about your readings please contact IMI at 707-823-0336 or, customercare@medcom.com.

Follow our blog at geigercounter.com and subscribe to our mailing list there to get the latest up-to-date information on radiation detection. We respect your privacy and will not share your email address with others.

Appendix: Technical Specifications

Detector:	Halogen-quenched Geiger-Mueller detector (LND 712) Mica end window density is 1.5–2.0 mg/cm^2 Side wall is 0.012" #446 stainless steel Detects Alpha, Beta, Gamma, and X-radiation
Display:	4-digit liquid crystal display with mode indicators
Operating Range:	µSv/hr: .000 to 1,100 mR/hr: .000 to 110 CPM: 0 to 350,000 CPS: 0 to 3,500 Total: 0 to 9,999,000 counts
Calibration:	Cesium-137 (gamma)
Gamma Sensitivity:	1,000 CPM/mR/hr referenced to Cs-137



Accuracy:	±10% typical; ±15% maximum
Timer:	Can set sampling periods of 1 minute to 40 hours
Averaging Periods:	Display updates every 3 seconds, showing the average for the past 90-second time period at normal levels. The averaging period decreases as the radiation level increases.

Count Light:	Red LED flashes with each count
Audio:	Beeper chirps for each count (can be muted)
Ports:	• Output: Stereo 3.5 mm jack sends counts to computers, data loggers, other CMOS-compatible devices, earphones, and educational data collection systems. 0–9 V, 1 kOhm impedance. • Input: 2.5 mm mono jack provides calibration input. 0–3.3 V, > 5 µs width, rising edge triggered.
Anti-Saturation:	Readout holds at full scale in fields up to 100 times the maximum reading
Temperature Range:	-20° to +50° C , -4° to +122° F
Power:	One 9-volt alkaline battery; battery life 2,000 hours typical, 700 hours minimum at normal background radiation levels at sea level. Battery life decreases as radiation level rises.
Size:	150 x 80 x 30 mm (5.9" x 3.2" x 1.2")
Weight:	225 grams (8 oz) including battery
Options:	Computer software and cable available
Certifications:	CE Certified: Emissions: EN 55011:2009 +A1:2010 (Class B emissions limits); EN 61326-1:2006 (Class B) RF Emissions Immunity: EN 61326-1:2006 (Annex C) Portable Test and Measurement Equipment; EN 61000-4-2:1995 (ESD); EN 61000-4-3:1997 (EM) RoHS Compliant Meets WEEE standards

Specifications subject to change without notice.

Limited Warranty

This product is warranted to the original owner to be free from defects in materials and workmanship for two years from the date of purchase with the exception of the Geiger-Mueller tube, which is warranted for one year. The battery is not included in this warranty. IMI-International Medcom, Inc. will, at its own discretion, repair or replace this instrument if it fails to operate properly within this warranty period provided that it has not been subjected to misuse, abuse, or neglect. Modification or repair of this instrument by anyone other than IMI voids this warranty.

Contamination of this instrument with radioactive materials voids this warranty. Contaminated instruments will not be accepted for servicing at our repair facility.

The user is responsible for determining the suitability of this product for the intended application. The user assumes all risk and liability connected with such use, IMI is not responsible for incidental or consequential damages arising from the use of this instrument.

The terms of this warranty are subject to change without notice.

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