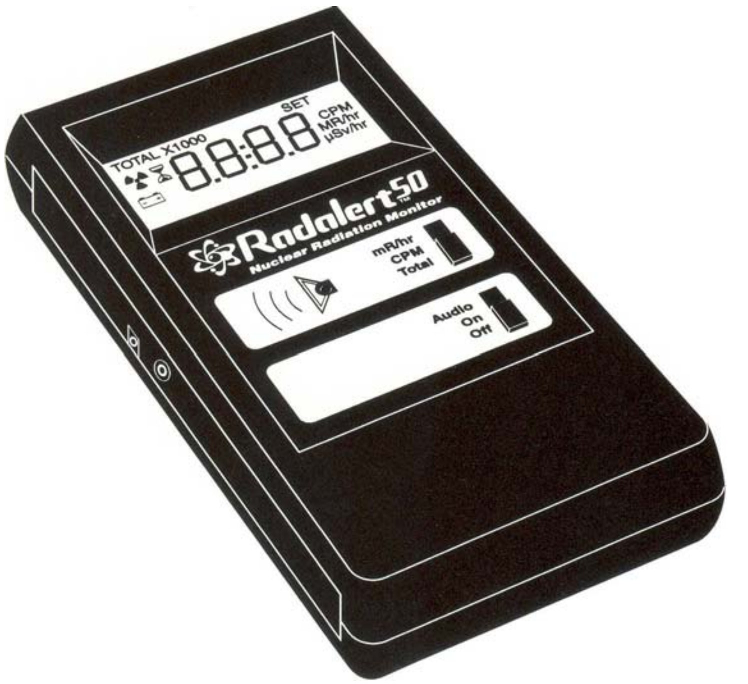
Radalert50™

Nuclear Radiation Monitor



Operating Manual

Radalert 50

Nuclear Radiation Monitor

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Contents

1 Introduction

The Radalert™ 50 is a health and safety instrument that measures alpha, beta, and gamma radiation. With the Radalert 50, you can:

- Monitor possible radiation exposure while working near radionuclides
- Ensure compliance with regulatory standards
- Check for leakage from X-ray machines and other sources
- Set the alert level and use the Radalert 50 in Alert mode; if the radiation goes above the level you set, the alert beeper sounds to let you know
- Screen for environmental contamination or environmental sources of radioactivity
- Connect the Radalert 50 to a computer or data logger to record and tabulate your data

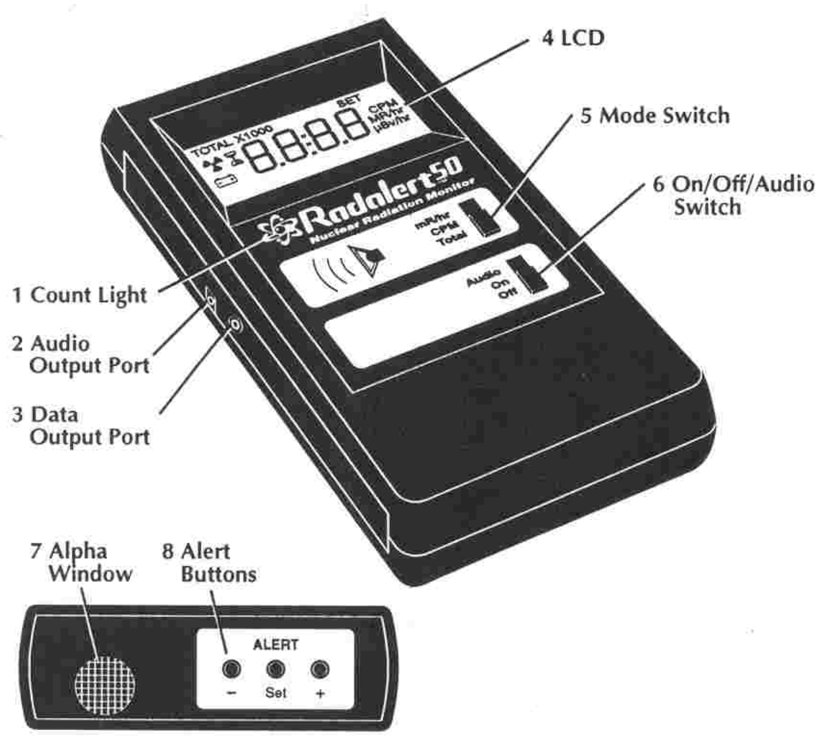
This manual gives complete instructions for using the Radalert 50 and procedures for common applications.

How the Radalert 50 Detects Radiation

The Radalert 50 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 Radalert 50 displays the counts in the mode you choose: counts per minute (CPM), milliroentgens per hour (mR/hr), or total counts.

2 Features

The Radalert 50 measures alpha, beta, gamma, and x-ray radiation. This chapter briefly describes the Radalert 50's functions. For more information on how to use the Radalert 50, see' Chapter 3, "Operation."

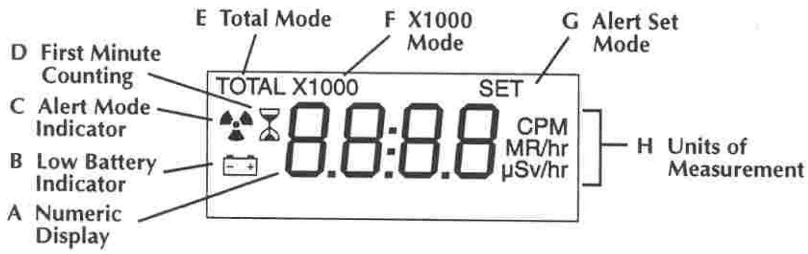


The Radalert 50 counts ionizing events and displays the results on the liquid crystal display (LCD) (**4**). You control which unit of measurement is shown by using the mode switch.

Whenever the Radalert 50 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.
- A **radiation warning icon** (**C**) appears when the Radalert 50 is in Alert-mode.
- An **hourglass** (**D**) appears to the left of the numeric display during the first minute the Radalert 50 is operating, to show that the reading is not yet complete.
- **TOTAL** (**E**) appears when the Radalert 50 is in Total mode.
- **X1000** (**F**) appears when the radiation level is displayed in X 1 000 mode.
- **SET** (**G**) appears when you are setting the alert level.
- The current **unit of measurement** (**H**)-**CPM** or **mR/hr**-is displayed to the right of the numeric display. The European version of the Radalert 50 uses µSv/hr rather than mR/hr.

The Switches

The Radalert 50 has two switches on the front, and three buttons on the end panel. Each switch has three settings, which are described below.

On/Off/Audio Switch (6)

Audio. The Radalert 50 is on, and it makes a clicking sound for each radiation event detected.

On. The Radalert 50 is operating, but audio is off.

Off. The Radalert 50 is not operating.

Mode Switch (5)

mR/hr. The numeric display shows the current radiation level in milliroentgens per hour from .001 to 50.

CPM. The display shows the current radiation level in counts per minute from 0 to 50,000. When X1000 is shown, multiply the numeric reading by 1000 to get the complete reading.

Total. The display shows the accumulated total of counts starting when the switch is turned to this position, from 0 to 60,000. When X1000 is shown, multiply the numeric reading by 1000 to get the complete reading.

The Alert Buttons (8)

The Set button turns Alert mode on and off and allows you to adjust the alert levels. The + and - buttons adjust alert levels, using the numeric display. For more information, see "Using the Alert" in Chapter 3.

The Detector

The Radalert 50 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 Radalert 50 is called the window. 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 is fragile. Be careful not to let anything penetrate the screen.*

The Ports

There are two ports on the left side of the Radalert 50.

The **audio output** (**2**) on the side of the Radalert 50 allows you to interface the Radalert 50 to an external speaker, amplifier, or tape recorder using a 2.5 mm plug.

The **data output port** (**3**) below the audio output port allows you to interface the Radalert 50 to a computer, data logger, 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 Radalert 50.

Starting the Radalert 50

Be sure that a standard 9-volt alkaline battery is installed in the battery compartment in the lower rear of the Radalert 50. *Note:* When installing the battery, place the battery wires along the side of the battery and not under it.

To start the Radalert 50, set the top switch to the mode you want, and set the bottom switch to **On** or **Audio**. The Radalert 50 then does a three-second system check, displaying all the indicators and numbers.

After the system check, the radiation level is displayed in the selected mode. In mR/hr and CPM mode, the display shows the accumulated reading for the first minute, with the hourglass icon to show that the first minute's reading is not yet complete. One minute after you start the Radalert 50, the hourglass disappears.

Operating Modes

When the mode switch is set to **mR/hr** or **CPM**, the numeric display is updated every minute.

CPM and total counts are the most direct methods of measurement; mR/hr is calculated using a conversion factor optimized for Cesium-137, so this mode is less accurate for other radionuclides. It is more appropriate to measure alpha and beta activity using CPM than using mR/hr. Conversion for alpha and beta emitters is calculated differently, and the Radalert 50's reading in mR/hr may not be accurate.

The most immediate indicators of the radiation level are the count light, the audio beep, and the alert. An increase is not shown on the numeric display in CPM and mR/hr modes until the end of a full minute.

Operating Ranges

The following table shows the radiation levels the Radalert 50 measures in each mode and how they are displayed. When radiation levels increase over certain preset levels, the Radalert 50 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.

Mode	Normal Range	X1000 Range
mR/hr	.001-50	NA
CPM	0-9999	10,000-50,000 (displayed as 10.00-50.00, with X1000 indicator)
Total	0-9999	10,000-60,000 (displayed as 10.00-60.00, with X1000 indicator)

Maximum level. When the maximum level for the current mode is reached, the numeric display remains at the maximum level and a small arrow is shown at the bottom right of the display.

Taking a Total Count

When the mode switch is set to **Total**, the Radalert 50 starts totaling the counts it registers, and the numeric display is updated each time a count is registered.

A total count is useful for determining the average counts per minute over a period of time. The number of counts detected by the Radalert 50 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.

Follow these steps to take a total count:

1 Place the Radalert 50 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**.

4 At the end of the time period, note the time and the number of counts 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 counts by the number of minutes in the timing period.

The average count is in counts per minute. To convert to mR/hr for Cesium-137, divide by 1000.

Using the Alert

The Radalert 50 can sound an audible alert whenever the radiation reading reaches a certain level. The three buttons on the end of the Radalert 50 allow you to turn Alert mode on and off and to set the alert levels.

The Alert Set button switches among three settings: Set, On, and Off. When you first press the Set button, the current alert level is displayed. It is in either CPM or mR/hr, depending on the setting of the mode switch. At this time, you can use the + and - buttons to adjust the alert level up or down. You can set the alert level in increments of 1 CPM (.001 mR/hr) up to 100 CPM (.1 mR/hr); in increments of 10 CPM (.01 mR/hr) up to 1000 CPM (1 mR/hr); and in increments of 500 CPM (.5mR/hr) above 1000 CPM (1 mR/hr). When the alert level is correct, press the Set button again to save the new level and continue in Alert mode. To turn off Alert mode, press the Set button again. While you are in Alert mode, to reset the alert level, press the Set button twice (Off, then Set).

When you start Alert mode, the Radalert 50 restarts counting, and the hourglass indicator is shown until the end of the first minute to show that the reading is not yet complete. While Alert mode is active, a radiation warning symbol is shown to the left of the numeric display.

When you first start the Radalert 50, the alert levels are preset at 100 CPM and .1 mR/hr, which are equivalent. If you set the alert level in mR/hr, the CPM level is automatically updated to the equivalent setting, and vice versa.

While you are in Alert mode, any time the radiation reaches the alert level, the audible alert sounds. The alert sounds before the current minute is complete, so the display still shows the reading for the previous minute. Watch the display until the end of the minute to see the reading that has triggered the alert.

The best alert level is one that rarely gives a false alarm, yet warns you when the radiation is higher than normal. See "Determining What Is a High Reading" in Chapter 6 for one method of finding this level.

Interfacing to an External Device

The upper output jack on the left side of the Radalert 50 provides audio output (a click for each count) through a 2.5 mm plug to an external audio amplifier, earpiece, or tape recorder.

The lower jack is a dual miniature jack that provides a data output that can be used to drive a CMOS or TIL device. 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 output at the tip of the plug provides a positive (5 volt) pulse each time the Geiger tube detects a count. A cable with an RS-232 connector for an IBM PC-compatible computer serial port and accompanying software are available from International Medcom or your distributor.

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 differ 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 Radalert 50, 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 total count. Use the steps shown in "Taking a Total Count" in Chapter 3 to get a ten-minute average.

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

Environmental Area Monitoring

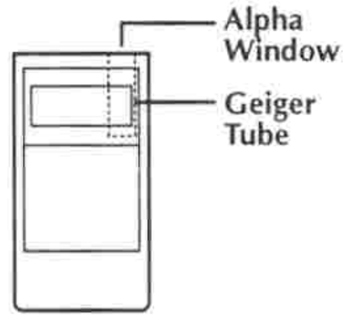
You can keep the Radalert 50 in CPM or mR/hr mode whenever you want to monitor the ambient radiation, and look at it from time to time to check for elevated readings. You can also use Alert mode to warn you if the radiation increases above the alert level.

If you suspect an increase in ambient radiation, take a five or 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, put the Radalert 50 next to it. The end window should be facing and close to the object; otherwise you may miss alpha and low-level beta radiation. If you want to find out if an object is slightly radioactive, place the Radalert 50 next to it and take an accumulated count over an appropriate period of time.

When you are not using the end window, hold the Radalert 50 so that the side wall of the tube is as close as possible to the object. The best position is with the top right of the back of the Radalert 50 closest to the object. The illustration at the right shows the position of the Geiger tube in the Radalert 50.



To measure as much as possible of the radioactivity of an object, place the Radalert 50 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 Radalert 50 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

Precautions

To keep the Radalert 50 in good condition, handle it with care, and observe the following precautions:

- Do not contaminate the Radalert 50 by touching it to radioactive surfaces or materials.
- Do not leave the Radalert 50 in temperatures over 1000 F (380 C) or in direct sunlight for extended periods of time.
- Do not get the Radalert 50 wet. Water can damage the circuitry and the coating of the mica surface of the Geiger tube.
- Avoid making measurements with the detector window in direct sunlight; this could affect the readings if the coating of the mica surface of the Geiger tube has been damaged by moisture or abrasion.
- Do not put the Radalert 50 in a microwave oven. It cannot measure microwaves, and you may damage it or the oven.
- Avoid using the Radalert 50 in high-intensity radio frequency, microwave, electrostatic, and electromagnetic fields; it may be sensitive to these fields and may not operate properly.
- If you expect to not use the Radalert 50 for longer than one month, remove the battery to avoid damage from battery corrosion.
- Change the battery promptly when the battery indicator appears on the display.

Troubleshooting

The Radalert 50 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	What to Check
Display is blank	no battery, dead battery, poor battery connection	make sure a new 9-volt battery is firmly connected
	broken LCD	if count light and audio work, the LCD may need to be replaced
Display works, but no counts are registered	damaged Geiger tube	look through the window to check the mica surface of the tube; if it is wrinkled or a break is visible, it needs to be replaced
Reading is high, but another instrument has a normal reading in the same location	contamination	check the Radalert 50 with another instrument; clean the instrument with a damp cloth with mild detergent
	photosensitivity	remove from direct sunlight and ultraviolet sources; if the high count drops, the mica window coating may have washed off the Geiger tube due to getting wet; the tube will need to be replaced
	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
	continuous discharge	the Geiger tube needs to be replaced
	electromagnetic field	move the instrument away from possible sources of electromagnetic or radio frequency radiation

If the Radalert 50 requires servicing, please contact your distributor or the manufacturer at the following address:

International Medcom
6871 Abbott Avenue
Sebastopol, CA 95472
707 -823-0336, fax 707-823-7207

Do not attempt to repair the Radalert 50; it contains no user serviceable parts and you could void your warranty.

CAUTION: Do *not send* a *contaminated instrument for repair under any circumstances.*

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 Radalert 50 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 and its decay products.

Ionizing radiation is categorized into four types:

X-rays are usually manmade 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.

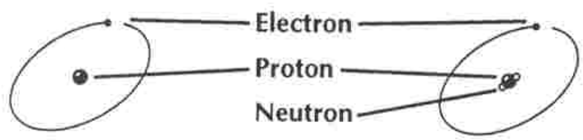
Gamma rays occur in nature and are almost identical to X-rays. Gamma rays generally have a shorter wavelength than X-rays. Gamma rays are very penetrating; thick lead shielding is generally required to stop them.

Beta radiation. A beta particle consists of an electron emitted from an atom. It has more mass and less energy than a gamma ray, so it 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 radionuclude 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 common isotope has no neutrons and is stable.

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

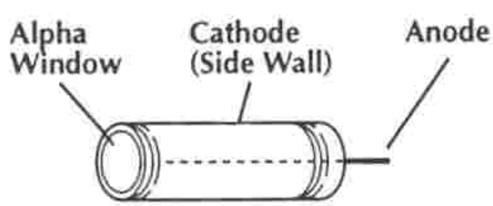
The following chart shows the complete decay chain for Uranium 238, which ends with a stable isotope of lead. Notice that the half-life of the radionuclides in the chain range from 164 microseconds to 4.5 billion years.

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-21 0	Lead
Pb-21 0	beta	21 years	Bi-210	Bismuth
Bi-210	beta	5 days	Po-21 0	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 measured by measuring the resulting ionization.

The Geiger tube used in the Radalert 50 consists of an anode and a cathode (positive and negative electrodes) separated 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 Radalert 50 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 Radalert 50 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 **bequerel** (Bq) is equivalent to one disintegration per second.

Determining What Is a High Reading

Due to the random nature of radioactivity, the Radalert 50 reading varies from minute to minute. In one location with only background radiation, the reading in mR/hr might vary in ten minutes from .007 to .018. In an hour, the reading might vary from .004 to .021. The averages for both periods would be very close.

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.

When monitoring radiation levels in one location, it's helpful to determine what reading is the highest you can normally expect to see in that location. If you use Alert mode, you want to set the alert level to one that rarely gives a false alarm, yet sounds the alert when the radiation is higher than normal.

You can experiment with different alert levels, or you can use a statistical method to determine the best alert level for your purposes. The procedure below uses standard deviation to determine what is an unusually high level in counts per minute. The result of the procedure is useful only for the same location.

A single alert may occur occasionally and is not significant unless there is also an elevation in the average count. If you suspect an elevation and you have previously taken an average background count in the same location, you can take a total count to get the current average count for 30 minutes or another period. You can then compare the current average to the previous average to see whether there is an elevation. See "Taking a Total Count" in Chapter 3 for more information.

First, find the standard deviation using the steps below. (Most computer spreadsheet programs have a formula for computing standard deviation, which you can use instead of steps 2-5.)

1 Use the Radalert 50 in (PM mode to measure counts for 30 or more consecutive minutes. Note each minute's count (The more readings you take, the more accurate your result)

2 Add the readings and divide the sum by 30 (or the number of readings) to get the average.

3 Find the difference between each reading and the average. Square each of these differences (multiply it by itself).

4 Total the squares of the differences and divide the sum by 29 (or the number of readings minus one).

5 Find the square root of this sum. This number is the standard deviation.

To find the highest normal reading you can expect, multiply the standard deviation by four and add it to the average from step 2 above.

For example, if the average counts per minute is 12.8 and the standard deviation is 4.3, add 4 X 4.3 to 12.8 to get 30. So 30 is the highest normal reading you're likely to get If you set the alert level to 31, you will get only an occasional alert for a high normal reading.

Note: This method is based on a bell curve type of distribution of values. The randomness of radioactivity fits a Poisson curve rather than a bell curve, but this method does yield an appropriate value.

Appendix A
Technical Specification

Sensor:	Halogen-quenched Geiger-Mueller tube with mica end window (LND 712 or equivalent). Mica window density 1.5-2.0 mg/cm^2. Side wall is .012” #446 stainless steel.
Display:	4-digit liquid crystal display with mode indicators
Operating Range:	mR/hr: .001 to 50 CPM: 0 to 50,000 Total: 1 to 60,000 counts μSv/hr: .01 to 500
Energy Sensitivity:	1000 CPM/mR/hr referenced to Cs-137
Accuracy:	±10% typical, ±15% maximum
Alert:	Beeper sounds the alert
Count light:	Red LED flashes with each count
Beeper:	Chirps for each count (can be muted)
Output:	Dual miniature jack sends counts to CMOS-compatible devices, including computers, data loggers, and educational data collection systems
Input:	Submini jack provides audio output to an external earpiece, amplifier, or tape recorder
Anti-Saturation:	“Jam” protection allows readout to hold at full scale in high radiation fields
Temperature Range:	-10° to +50° C , 14° to 122° F
Power:	One 9-volt alkaline battery
Size:	150 x 80 x 30 mm (5.9” x 3.2” x 1.2”)
Weight:	250 grams (9 oz) including battery

Warranty

This product is warranted to the original owner to be free from defects in materials and workmanship for one year from the date of purchase, except for the Geiger tube, which is warranted for 90 days. The battery is not included in the warranty. International Medcom will repair or replace your instrument if it fails to operate properly within this warranty period provided it has not been subjected to misuse, abuse, or neglect. Modification or repair of this instrument by anyone other than International Medcom voids this warranty. International Medcom is not responsible for incidental or consequential damages arising from the use of this instrument.

Contamination of the 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 usefulness of this product for his or her application.

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