



palmRAD 907
Nuclear Radiation Monitor
Operating Manual

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1 Introduction

The Model 907 is a health and safety instrument that is optimized to detect low levels of radiation. It measures alpha, beta, and gamma radiation. Its applications include:

- o Detecting and measuring surface contamination
- o Monitoring possible radiation exposure while working with radionuclides
- o Alerting you with an audible alarm if the radiation goes above an alert level that you set
- o Screening for environmental contamination
- o Detecting noble gases and low energy radionuclides

How the Model 907 Detects Radiation

The Model 907 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 Model 907 displays the counts in the mode you choose: microsieverts per hour ($\mu\text{Sv/hr}$), either counts per minute (CPM) or counts per second (CPS), or total counts. In conventional units, milliroentgens per hour (mR/hr) and CPM are used.

The number of counts detected by the Model 907 varies from reading to reading due to the random nature of radioactivity. A reading is expressed more accurately as an average over time, and the average is more accurate over a longer time period. For more information, see “Operating in Total/Timer Mode” in Chapter 3.

Precautions

To keep the Model 907 in good condition, handle it with care and observe the following precautions:

- Do not contaminate the Model 907 by touching it to radioactive surfaces or materials. If contamination is suspected, you may need to replace the rubber strips above and below the rear label.

- Do not leave the Model 907 in temperatures over 122° F (50° C) or in direct sunlight for extended periods of time.
- Do not get the Model 907 wet. Water can damage the circuitry and the coating of the mica surface of the Geiger tube.
- Do not put the Model 907 in a microwave oven. It cannot measure microwaves, and you may damage it or the oven.
- If you expect to not use the Model 907 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.

2 Features

The Model 907 measures alpha, beta, gamma, and X-ray radiation. It is optimized to detect small changes in radiation levels and to have high sensitivity to many common radionuclides. For more information, see the Appendix: Technical Specifications at the end of this manual.

This chapter briefly describes the Model 907's functions. For more information on how to use the Model 907, see Chapter 3, "Operation."

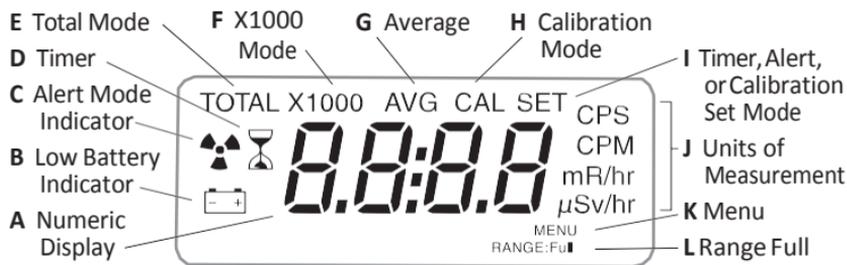
The Model 907 counts ionizing events and displays the results on the liquid crystal display (LCD) (4). You control which unit of measurement is shown by using the mode switch.



Whenever the Model 907 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 symbol (C)** appears when the Alert feature is on.
- An **hourglass (D)** appears during a timed count.
- **TOTAL (E)** appears when the Model 907 is in Total/Timer mode.
- **X1000 (F)** appears when the radiation level is displayed in X1000 mode.
- **AVG (G)** appears when the Model 907 is showing the average reading for a timed count.
- **CAL (H)** appears while you are calibrating the Model 907.
- **SET (I)** appears when you are setting the Timer, the Alert level, or 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 (J)**—CPM, CPS, mR/hr, or µSv/hr—is displayed to the right of the numeric display.
- **MENU (K)** appears when you are in the Utility Menu.

- **RANGE:Full (L)** appears when the radiation level goes beyond the range that can be displayed.

The Switches

The Model 907 has two switches on the front and three buttons on the end panel. Each switch has three settings, which are described below.

Mode Switch (6)

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 or in counts per second from 0 to 6500. 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 (7)

Audio. The Model 907 is on, and it makes a clicking sound for each radiation event detected.

On. The Model 907 is operating, but audio is off.

Off. The Model 907 is not operating.

+, -, and SET Buttons (8)

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

The Detector

CAUTION: The mica surface of the Geiger tube is fragile. Be careful not to let anything penetrate the screen.

The Model 907 uses a two-inch round Geiger tube, commonly called a “pancake tube.” The screen on the back of the Model 907 is called the window. It allows alpha and low-energy beta and gamma radiation, which cannot get through the plastic case and the stainless steel detector body, to penetrate the mica surface of the tube. The small radiation symbols on the front label (5) and the end label (9) indicate the center of the Geiger tube.



The Input/Output Ports

There are two ports on the left side of the Model 907.

The **calibration input port** (2) is used for calibrating electronically using a pulse generator. For more information, see “Calibrating Electronically” in Chapter 5.

The **output port** (3) below the calibration input port allows you to interface the Model 907 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 Model 907.

Units of Measurement

The Model 907 is designed both for users of SI units (microsieverts per hour and counts per second or 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 Model 907

Be sure that a standard 9-volt alkaline battery is installed in the battery compartment in the lower rear of the Model 907. You can also install the rubber strips supplied with the instrument as shown on the diagram provided with them. These strips provide a no-slip cushion for the Model 907 and protect the GM tube from possible contamination.

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

To start the Model 907, set the top switch to the mode you want, and set the bottom switch to **On** or **Audio**. The Model 907 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. Thirty seconds after you start the Model 907, a short beep indicates that enough information has been collected to ensure statistical validity.

When using the Model 907, 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, significant

changes in the radiation level displayed can take up to 30 seconds to stabilize. See “Operating Ranges and Response Times” in this chapter for more information.

Count Rate (CPM or CPS) and timed total counts are the most direct methods of measurement; Dose Rate ($\mu\text{Sv/hr}$ 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 than using Dose Rate. Conversion for alpha and beta emitters is calculated differently, and the Model 907’s Dose Rate reading may not be accurate.

The most immediate indicators of the radiation level are the count light, the audio beep, and the alert. 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 Model 907 starts totaling the counts it registers, and the numeric display is updated every second.

Taking a Timed Count

When a timed count is taken over a longer period, the average count per minute is more accurate, and any small increase is more significant. 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 may be statistically significant.

The Model 907 can give you a total count for a timed period of from one minute to 40 hours. Follow these steps:

1. With the Model 907 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 Model 907 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 Model 907 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 Model 907 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 Model 907 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 Model 907 measures in each mode and how they are displayed.

Mode	Regular Range	x1000 Range
$\mu\text{Sv/hr}$.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	0–6500	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 Inspector Alert 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 Model 907 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 6,000 CPM, the reading in the dose and count rate modes is based on the radiation detected in the immediately previous 30 seconds. In order to give a quicker response to changes, when the radiation level exceeds 6,000 CPM in any 30-second period, the reading is based on the previous 6 seconds, and when it exceeds 12,000 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 30 seconds)
<6000 CPM or <18 μ Sv/hr or <1.8 mR/hr (<100 CPS)	30 seconds
6000–12000 CPM or 18–36 μ Sv/hr or 1.8–3.6 mR/hr (100–200 CPS)	6 seconds
>12000 CPM or >36 μ Sv/hr or >3.6 mR/hr (>200 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.

Using the Alert

The Model 907 can sound an audible alert whenever the radiation reading reaches a certain level. The +, –, and Set buttons on the end of the Model 907 allow you to turn Alert mode on and off and to set the alert levels. You can set the alert level when the Mode switch is set to **Dose Rate** or **Count Rate**. Follow these steps:

1. Press the Set button on the end panel twice in quick succession. The display shows the current alert level in μ Sv/hr, mR/hr, CPM, or CPS, depending on the current setting. The radiation symbol and SET icon are also displayed.
2. To change the displayed alert level, use the + and – buttons to adjust the level up or down.
3. When the desired alert level is displayed, press the Set button once to save the new level and to continue in Alert mode. The radiation symbol is displayed to show that the Model 907 is in Alert mode.

4. To reset the alert level while you are in Alert mode, press the Set button four times (twice for Off, and twice more for Set), then repeat steps 2 and 3.
5. To turn off Alert mode, press the Set button twice.

When Alert mode is started, the Model 907 restarts counting, and beeps after 30 seconds to show that the reading is statistically valid.

When you first start the Model 907, the alert levels are preset at 1 $\mu\text{Sv/hr}$ and the equivalent values in the other units: .1 mR/hr, 330 CPM, and 5 CPS. If you set the alert level in one mode, the settings for the other modes are automatically updated to the equivalent values (the conversion may not be exact due to rounding). When you change the units of measurement, the alert level is reset to the defaults.

The best alert level is one that rarely gives a false alarm, yet warns you when the radiation is higher than normal.

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 Model 907 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 Model 907. 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 $\mu\text{Sv/hr}$ (the default) selects counts per minute and microsieverts per hour; CPM mR/hr selects counts per minute and milliroentgens per hour; CPS $\mu\text{Sv/hr}$ 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 $\mu\text{Sv/hr}$, and 100, and resets the Alert level to 1.000 $\mu\text{Sv/hr}$.
- 9 **Revision #.** Displays the software version number.

Interfacing to an External Device

The lower output jack on the left side of the Model 907 is a dual miniature jack that provides 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 input. The tip signal is approximately 80 microseconds wide and is suitable for high-speed counting and RS-232 interfacing.

Computer cables for USB or serial ports and accompanying software for Windows are available from Berkeley Nucleonics

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.

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, even in different areas of the same room. To accurately interpret the readings you get on the Model 907, 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 Model 907 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 Model 907 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 Model 907 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. If you need to determine whether there is prior 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 Model 907 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. 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, 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 for Surface Contamination

To check a surface, hold the Model 907 with the alpha window facing and close to the surface. To find out if a surface is slightly radioactive, place the Model 907 next to it and take a timed count or a longer accumulated count.

CAUTION: Never touch the Model 907 to an object that may be contaminated. You may contaminate the instrument. A contaminated instrument will not be accepted for repair or servicing. If you have fastened the rubber strips supplied with the Model 907 to the back of the instrument, you can remove them if they are contaminated. You can order replacement strips from Berkeley Nucleonics

5 Maintenance

The Model 907 should be handled with care and can be calibrated as necessary to comply with regulations. Use the following guidelines to maintain the Model 907 properly.

Calibration

The Model 907'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 list of recommended laboratories for instrument calibration, see the Berkeley Nucleonics website at medcom.com. Check sources are available from various licensed sources. 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 $\mu\text{Sv/hr}$ (66 mR/hr). Some labs can do a three-point calibration check at, for example, 250, 500, and 660 $\mu\text{Sv/hr}$ (25, 50, and 66 mR/hr). Calibration should not be done at levels below 10 $\mu\text{Sv/hr}$ (1mR/hr) or above 900 $\mu\text{Sv/hr}$ (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 Model 907's calibration procedure is designed to further minimize exposure.

Before you calibrate the Model 907, make sure the distance between

the Model 907 and the source is correct to produce the appropriate dose rate. Follow these steps:

1. Start with the Model 907 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/Audio** switch to **On**. (Don't use the **Audio** setting.)
The display shows **CAL**, and the Model 907 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 Model 907 beeps several times.
3. The Model 907 collects data for 30 seconds, beeping as it does so, with **CAL** and the hourglass indicator flashing. At the end of the 30 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 Model 907 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 Model 907 is first turned on.

Calibrating Electronically

You can calibrate the Model 907 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 to 3.3 volts (positive pulse).
2. Plug the cable into the upper jack.
3. Start with the Model 907 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 Model 907 counts down for 15 seconds, chirping each second. At the end of the 15 seconds, the Model 907 beeps several times.

4. The Model 907 collects data for 30 seconds, beeping as it does so, with **CAL** and the hourglass indicator flashing. At the end of the 30 seconds, it beeps several times. The display shows **CAL** and **SET**.
5. Use the following table to check the Model 907'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 Model 907 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	$\mu\text{Sv/hr}$	mR/hr	CPS
523.72	31,423	33,400	100	10	557
988.92	59,335	66,800	200	20	1,113
2,117.38	127,043	167,000	500	50	2,783
2,962.52	177,751	267,200	800	80	4,453
3,417.16	205,032	334,000	1,000	100	5,567

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 Model 907 beeps and resumes regular operation.

Troubleshooting and Service

The Model 907 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
	Damaged LCD	If count light and audio work, the LCD may need to be replaced
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 Model 907 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 damaged 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., electromagnetic or microwave

If the Model 907 requires servicing, please contact your distributor or Berkeley Nucleonics for instructions on where to ship the instrument. You can contact Berkeley Nucleonics at 707-823-0336 or at contact@medcom.com.

Do not attempt to repair the Model 907; 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 Model 907 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 detected by the Model 907 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.

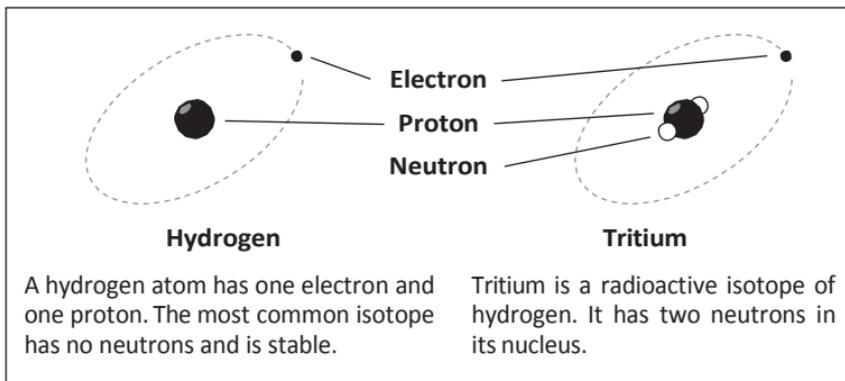
Gamma rays occur in nature and are almost identical to X-rays, but generally have a shorter wavelength than X-rays. Gamma rays are very penetrating; thick lead shielding is generally required to stop them.

Beta radiation. A beta particle consists of an electron emitted from an atom. It has 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 radionuclide has a half-life, which is the time required for half of a quantity of the material to decay.



The chart on the following page 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-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

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 Model 907 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.

Appendix: Technical Specifications

Detector:	Halogen-quenched Geiger-Mueller tube Effective diameter 1.75" (45 mm) Mica window density 1.5–2.0 mg/cm ² Detects Alpha, Beta, Gamma, and X-radiation	
Display:	4-digit liquid crystal display with mode indicators	
Operating Range:	μ Sv/hr: .000 to 1,100 mR/hr: .000 to 110 CPM: 0 to 350,000 CPS: 0 to 6,500 Total: 0 to 9,999,000 counts	
Calibration:	Cesium-137 (gamma)	
Gamma Sensitivity:	3,340 CPM/mR/hr referenced to Cs-137 Smallest detectable level for I-125 is .02 mCi at contact	
Efficiency:	For 4 pi at contact:	
Isotope	Energy	Efficiency
C-14 (Beta) Bi-210 (Beta) Sr-90 (Beta) P-32 (Beta)	49 keV avg. 156 keV max.	5.3%
	390 keV avg. 1.2 MeV max.	32%
	546 keV and 2.3 MeV	38%
Am-241 (Alpha)	693 keV avg. 1.7 MeV max.	33%
	5.5 MeV	18%
ENERGY RESPONSE CURVE		
Accuracy:	±10% typical; ±15% maximum	

Alert Range:	<p> $\mu\text{Sv/hr}$: .001 to 500 mR/hr: .001 to 50 CPM: 1 to 165,000 CPS: 1 to 2,700 Beeper sounds the alert </p>
Timer:	Can set sampling periods of 1 minute to 40 hours
Averaging Periods:	Display updates every 3 seconds, showing the average for the past 30-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:	<p> o 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. o Input: 2.5 mm mono jack provides calibration input. 0–3.3 V, > 5 μs width, rising edge triggered. </p>
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:	323 grams (11.4 oz) including battery
Options:	Computer software and cable available
Certifications:	<p> 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 </p>

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. Berkeley Nucleonics 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 Berkeley Nucleonics 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. Berkeley Nucleonics 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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