

 **Inspector**  
**ALERT™**  
**Nuclear Radiation Monitor**



# Operating Manual

# **Inspector Alert**

**Nuclear Radiation Monitor**

**Operating Manual**

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# 1 Introduction

The Inspector Alert 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:

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

## How the Inspector Alert Detects Radiation

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

The number of counts detected by the Inspector Alert 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

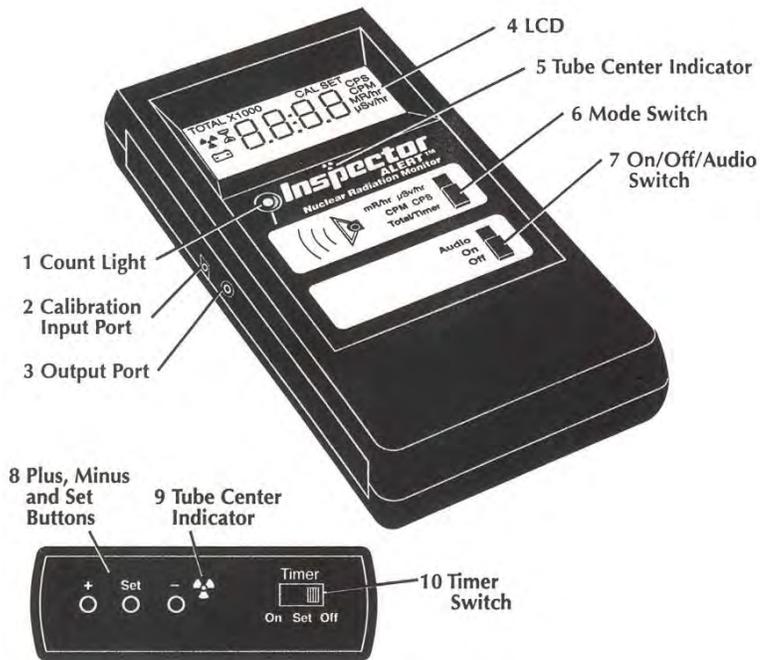
To keep the Inspector Alert in good condition, handle it with care, and observe the following precautions:

- Do not contaminate the Inspector Alert by touching it to radioactive surfaces or materials. If contamination is suspected, you can replace the rubber strips above and below the rear label with the extra strips supplied with the Inspector Alert.
- Do not leave the Inspector Alert in temperatures over 122° F (50° C) or in direct sunlight for extended periods of time.
- Do not get the Inspector Alert 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 Inspector Alert in a microwave oven. It cannot measure microwaves, and you may damage it or the oven.
- If you expect to not use the Inspector Alert 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 Inspector Alert 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 Appendix A, "Technical Specifications."

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

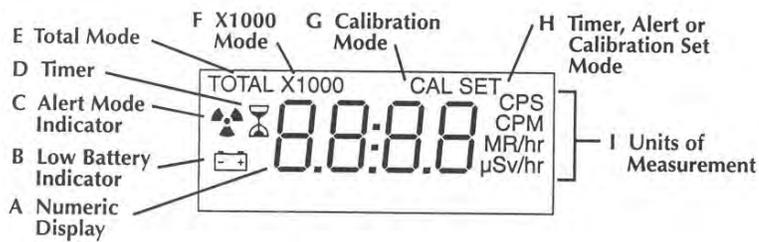


The Inspector Alert counts ionizing events and displays the results on the liquid crystal display (LCD) (4). You control which unit of measurement is shown by using the mode switch.

Whenever the Inspector Alert 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 Inspector Alert is in Total/Timer mode.
- **X1000** (F) appears when the radiation level is displayed in X1000 mode.
- **MENU** (not shown) appears when you are in the Utility menu.

- **CAL (G)** appears while you are calibrating the Inspector Alert.
- **SET (H)** appears when you are setting the timer, the Alert level, and the calibration factor, or working in the Utility menu (the numeric display shows the setting you are adjusting 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.

## The Switches

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

### On/Off/Audio Switch (7)

**Audio.** The Inspector Alert is on, and it makes a clicking sound for each radiation event detected.

**On.** The Inspector Alert is operating, but audio is off.

**Off.** The Inspector Alert is not operating.

### Mode Switch (6)

**mR/hr μSv/hr.** The numeric display shows the current radiation level in milliroentgens per hour from .001 to 100. When SI units are used, it shows the current radiation level in microseiverts per hour, from .01 to 1000.

**CPM CPS.** 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 1000 to get the complete reading. When SI units are used, the display shows the current radiation level in counts per second from 0 to 5000.

**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 1000 to get the complete reading.

## Timer Switch (10)

**Off.** The timer is not operating.

**Set.** You can now set the length of the timed period using the + and - buttons. If the timer is already operating, the display shows the time remaining in the timed period.

**On.** The timer is operating, and the display shows the total counts so far in the timed period.

## + , - , 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.*

### Internal—For Inspector Alert Only

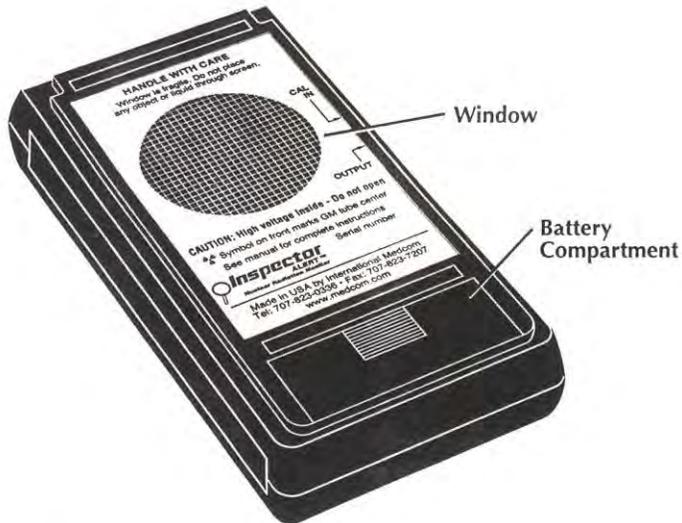
The Inspector Alert uses a two-inch round Geiger tube, commonly called a "pancake tube." The screen on the back of the Inspector Alert is called the window. It allows alpha and low-energy beta and gamma radiation, which cannot get through the plastic case and the stainless steel detector body, to penetrate 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.

### External—For Inspector Alert EXP Only

The Inspector Alert EXP has the pancake detector in an external probe instead of inside the instrument. To connect the probe, plug one end of the cable into the connector on the end of the Inspector Alert EXP and the other end to the probe.

**CAUTION:** The connectors are directional. Be sure to line them up properly before fitting them together. If the probe is not connected when you turn the Inspector Alert EXP on, the instrument will not function properly.

**CAUTION:** Do not remove the probe while the instrument is on.



## The Input/Output Ports

There are two ports on the left side of the Inspector Alert. The Inspector Alert EXP has a third port on the end panel.

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 Inspector Alert 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.

The **probe port** on the end panel of the Inspector Alert EXP allows you to plug the external probe into the instrument.

## 3 Operation

The guidelines in this chapter describe how to use the Inspector Alert.

### Units of Measurement

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

### Starting the Inspector Alert

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

Before you start the Inspector Alert, make sure the timer switch on the end panel is set to **Off**.

To start the Inspector Alert, set the top switch to the mode you want, and set the bottom switch to **On** or **Audio**. The Inspector Alert then does a four-second 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 Inspector Alert, a short beep indicates that enough information has been collected to ensure statistical validity.

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

## Operating in the Dose Rate Modes

When the mode switch is set to **mR/hr** **μSv/hr** or **CPM** **CPS**, 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.

CPM (or CPS) and total counts are the most direct methods of measurement; mR/hr (or μSv/hr) is calculated using a conversion factor optimized for Cesium-137, so this mode is less accurate for other radionuclides, unless you have calibrated the Inspector Alert for a specific radionuclide using an appropriate source. 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 Inspector Alert’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. It takes three seconds before an increase is shown on the numeric display in the dose rate modes.

## Operating in Total/Timer Mode

When the mode switch is set to **Total/Timer**, the Inspector Alert 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 Inspector Alert can give you a total count for a timed period of from one minute to 24 hours. Follow these steps:

1. With the Inspector Alert operating, set the Mode switch to **Total/Timer**. The display shows **TOTAL**.
2. Set the Timer switch on the end panel to **Set**. The display shows **SET**, the hourglass, and the most recent timing period used. The first time you use the timer, the setting is 00:01, which means one minute.
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 to 50 minutes in ten-minute increments, or for 1 to 24 hours in one-hour increments.
4. Set the Timer switch to **On**. The Inspector Alert beeps three times and starts counting. The hourglass indicator flashes during the timed period.

If you want to see how many minutes remain, set the Timer switch to **Set**. The display counts down from the time setting in hours and minutes to zero. For example, if the display says 00:21, 21 minutes remain. Be sure to set the switch back to **On** to see the total count when the timed period is finished.

5. At the end of the timed period, the Inspector Alert beeps three times, and repeats the beeping several times. The number displayed is the total count.
6. To find the average dose rate for the timed period in counts per minute, divide the total by the number of minutes.
7. Set the Timer switch to **Off** to return to normal operation.

As long as the Timer switch is set to **On**, the timer mode is active in the background even when the Mode switch is set to one of the dose rate modes. For example, during and after the timed period, you can switch back and forth between **Total/Timer** and **mR/hr**; 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 twenty-four hours. In certain situations, you may want to take a total count without the timer; for example, taking a count for longer than twenty-four hours. Follow these steps:

1. Place the Inspector Alert 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 Inspector Alert 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 Inspector Alert measures in each mode and how they are displayed.

Mode	Regular Range	X1000 Range
mR/hr	.001-110	NA
μSv/hr	.01-1100	NA
CPM	0-9999	10,000-350,000 (displayed as 10.00-350, with X1000 indicator)
CPS	0-5000	NA
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 numeric display flashes. The beeping pattern and the flashing continue until the level decreases or the Inspector Alert is turned off.

**Display update and response time.** In Total/Timer mode, the numeric display is updated each second. In the dose rate modes, the numeric display is updated every three seconds. When the radiation level is less than 6,000 CPM, the reading in any of the dose 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.

<b>Radiation level</b>	<b>Basis for reading (after first 30 seconds)</b>
< 6000 CPM or < 1.75 mR/hr (< 100 CPS)	30 seconds
6000-12000 CPM or 1.75-3.6 mR/hr (100-200-CPS)	6 seconds
> 12000 CPM 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 Inspector Alert can sound an audible alert whenever the radiation reading reaches a certain level. The +, -, and Set buttons on the end of the Inspector Alert allow you to turn Alert mode on and off and to set the alert levels.

To use Alert mode, follow these steps:

1. Press the Set button on the end panel. The current alert level is displayed. It is in CPM, CPS, mR/hr, or  $\mu$ Sv/hr, depending on the Inspector Alert’s current settings. The radiation symbol and **SET** icon are displayed.
2. If you want 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 again to save the new level and continue in Alert mode.  
The radiation symbol is displayed to show that the Inspector Alert is in Alert mode.
4. If you want to reset the alert level while you are in Alert mode, press the Set button twice (Off, then Set).

5. To turn off Alert mode, press the Set button once.

When you start Alert mode, the Inspector Alert restarts counting, and beeps after 30 seconds to show that the reading is statistically valid.

When you first start the Inspector Alert, the alert levels are preset at .10 mR/hr, and the equivalent in CPM,  $\mu\text{Sv}$ , and CPS. If you set the alert level in one mode, the settings for the other modes are automatically updated to the equivalent values.

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 you change a setting, it remains in effect after you turn off the Inspector Alert and until you change it again.

To activate the Utility Menu, hold down the + button on the end panel while you turn on the Inspector Alert. 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 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 mR/hr** selects counts per minute and milliroentgens per hour; **CPS  $\mu\text{Sv/hr}$**  selects counts per second and microseiverts per hour.
- 3 Cal 100 Reset.** Selecting this option automatically resets the calibration factor to 100 and restarts the instrument.

- 4, 5, 6** Reserved for future options.
- 7 Cal Factor Adjust.** Displays the current calibration factor, which you then adjust to the new factor you want. See “Calibration” in Chapter 5.
- 8 Factory Default Reset.** Selecting this option automatically resets the items 1, 2, and 3 to Auto averaging, CPM and mR/hr, and 100, and restarts the instrument
- 9 Revision #.** Displays the software version number.

## Interfacing to an External Device

The lower output jack on the left side of the Inspector Alert is a dual miniature jack that provides a data output that can be used to drive a CMOS or TTL 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 (3.3 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.

## 4 Common Procedures

The following sections give instructions 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 Inspector Alert, 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 Inspector Alert operating, set the Mode switch to **Total/Timer**.
2. Set the Timer switch on the end panel to **Set**. Unless you have previously changed it, the display reads 00:01, which means one minute.
3. Press the + button nine times. The display should read 00:10, for ten minutes.
4. Set the Timer switch to **On**. The Inspector Alert beeps three times and starts counting.

If you want to see how much of the ten minutes remains, set the Timer switch to **Set**. The display counts down from ten minutes to zero. For example, if the display says 00:03, seven minutes have passed and three minutes remain. Reset the switch to **On** to return to the radiation level display.

5. At the end of the ten minutes, the Inspector Alert beeps three times, and repeats the beeping several times. Note the total reading.
6. To find the average counts per minute, divide the total by ten (the number of minutes).

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 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 Inspector Alert 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, use the timer to 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 for Surface Contamination**

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

**CAUTION:** *Never touch the Inspector Alert to a surface that may be contaminated. You may contaminate the instrument. The rubber strips on the back can be replaced if they become contaminated. Replacement strips are supplied with the Inspector Alert.*

## 5 Maintenance

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

### Calibration

The Inspector Alert should be calibrated as often as your regulations require. The best way to calibrate is using a calibrated source. If no source is available, it is possible to calibrate electronically using a pulse generator.

The standard radionuclide for calibration is Cesium-137. A certified calibration source should be used. To calibrate the Inspector Alert for another radionuclide, you must use a calibrated source for that radionuclide or the appropriate conversion factor referenced to Cs-137.

**CAUTION:** *In calibration mode, the smallest increment that can be adjusted is .010, which prevents fine adjustment of the calibration factor. Thus, errors can occur if you use a low-level source or background to set the calibration factor.*

### Calibrating Using a Source

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

1. Start with the Inspector Alert turned off and the Mode switch set to **mR/hr  $\mu$ Sv/hr**.
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 Inspector Alert 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 Inspector Alert beeps several times.

3. The Inspector Alert 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 Inspector Alert 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 Inspector Alert is first turned on.

### Calibrating Electronically

You can calibrate 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) and the pulse width to 80 microseconds.

**CAUTION:** Do not inject a pulse when the Inspector Alert is turned off. Do not exceed 5 volts.

2. Plug the cable into the upper jack.
3. Start with the Inspector Alert turned off and the Mode switch set to **mR/hr  $\mu$ Sv/hr**. 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 Inspector Alert counts down for 15 seconds, chirping each second. At the end of the 15 seconds, the Inspector Alert beeps several times.

4. The Inspector Alert 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**.

- Use the following table to check the Inspector Alert's accuracy. The table shows appropriate pulse generator count rates to calibrate for Cs137. If the accuracy is not within desired limits, follow steps 5-7. Note that the Inspector Alert 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.

<b>Pulse Generator Input (PPM)</b>	<b>CPM</b>	<b>mR/hr</b>	<b>μSv/hr</b>	<b>CPS</b>
31,423	33,400	10	100	557
59,335	66,800	20	200	1,113
127,043	166,999	50	500	2,783
177,752	267,200	80	800	4,453
205,031	334,031	100	1,000	5,567

- 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.
- The new calibration factor is displayed for several seconds, then the Inspector Alert beeps and resumes regular operation.

## Troubleshooting

The Inspector Alert 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.

<b>Problem</b>	<b>Possible Cause</b>	<b>What To Check</b>
Display is blank	no battery, dead battery, poor battery connection	make sure a new 9-volt battery is firmly connected
	broken LCD	if the 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
	bad cable connection (EXP only)	check to make sure the cable is connected correctly
Reading is high, but another instrument has a normal reading in the same location	contamination	check the Inspector Alert with another instrument; clean the instrument with a damp cloth with mild detergent and replace the rubber strips on the back of the instrument
	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

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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	replace the Geiger tube
electromagnetic field	move the instrument away from possible sources of electromagnetic or radio frequency radiation

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## Service

If the Inspector Alert requires servicing, please contact your distributor or the manufacturer:

International Medcom  
707-823-0336, fax 707-823-7207  
<http://www.medcom.com>

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

**CAUTION:** *Do not send a contaminated instrument for repair or calibration 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 Inspector Alert 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 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-ionizing, 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 following chart shows the complete decay chain for Uranium 238, which ends with a stable isotope of lead. Notice that the half-lives 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 it, 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 Inspector Alert displays readings in milliroentgens per hour (mR/hr).

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 are the most commonly-used measurement units of radiation dose in the U.S. In most cases, one rem equals one rad.

A **sievert** is the standard international measurement of dose. One sievert is equivalent to one hundred rems. A microsievert ( $\mu\text{Sv}$ ) 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.

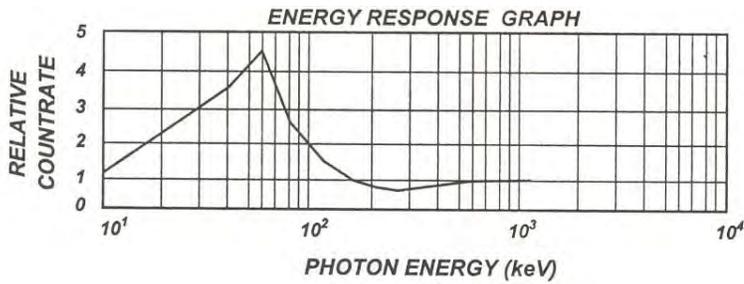
A **becquerel** (Bq) is equivalent to one disintegration per second.

# Appendix A

## Technical Specifications

- Detector:** Halogen-quenched Geiger-Mueller tube.  
Effective diameter 1.75" (45 mm). Mica window density 1.5-2.0 mg/cm<sup>2</sup>.  
EXP only: Same detector in anodized aluminum housing with black vinyl grip. 500 volt power supply is located in the probe head. Amphenol Tugal connectors.
- Display:** 4-digit liquid crystal display including mode indicators
- Operating Range:** mR/hr: .001 to 100.0  
CPM: 0 to 350,000  
Total: 1 to 9,999,000 counts  
 $\mu$ Sv/hr: .01 to 1,000  
CPS: 0 to 5,000
- Gamma Sensitivity:** 3500 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
<b>Beta</b>		
C-14	49 keV avg. 156 keV max.	5.3%
Bi-210	390 keV avg. 1.2 MeV max.	32%
Sr-90	546 keV and 2.3 MeV	38%
P-32	693 keV avg. 1.7 MeV max.	33%
<b>Alpha</b>		
Am-241	5.5 MeV	18%



- 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.
- Timer:** Can set 1-10 minute sampling periods in one-minute increments, 10-50 minute sampling periods in 10-minute increments, and 1-24 hour sampling periods in 1-hour increments
- Alert** Beeper sounds the alert
- Accuracy:** mR/hr:  $\pm 15\%$  up to 50 mR/hr  
 $\pm 20\%$  up to 100 mR/hr  
 CPM:  $\pm 15\%$  up to 130,000 CPM  
 $\pm 20\%$  from 130,000 to 350,000 CPM
- Anti-Saturation:** Readout holds at full scale in fields up to 100 times the maximum reading
- Temperature Range:**  $-20^{\circ}$  to  $+50^{\circ}$  C ,  $-4^{\circ}$  to  $+122^{\circ}$  F
- Power:** One 9-volt alkaline battery; battery life is average 2160 hours at normal background, average 625 hours at 1 mR/hr with beeper off
- Size:** 150 x 80 x 30 mm (5.9" x 3.2" x 1.2")
- Weight:** 323 grams (11.4 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.

International Medcom

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