Digilert-50

Nuclear Radiation Monitor
Operation Manual

10/97

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1 Introduction

The Digilert 50 is a health and safety instrument that measures alpha, beta, and gamma radiation.

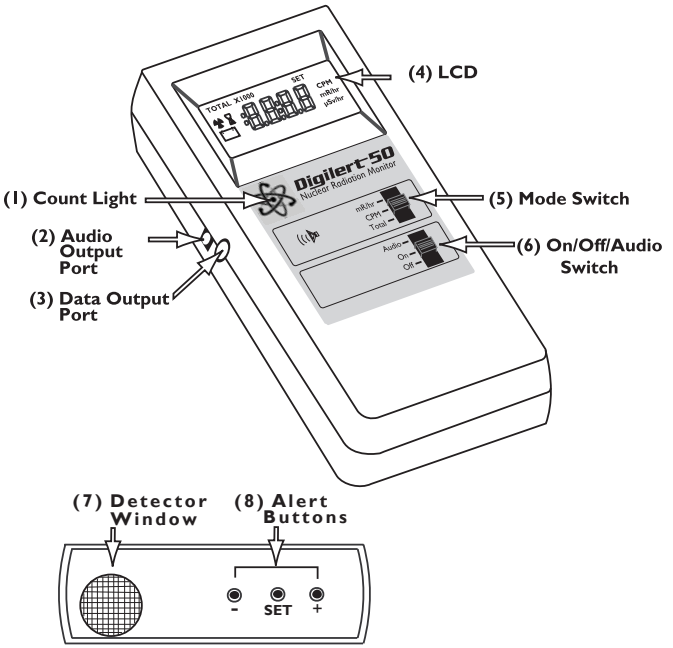
Precautions

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

- Do not contaminate the Digilert 50 by touching it to radioactive surfaces or materials.
- Do not leave the Digilert 50 in temperatures over 100° F (38° C) or in direct sunlight for extended periods of time.
- Do not get the Digilert 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.
- Do not put the Digilert 50 in a microwave oven. It cannot measure microwaves, and you may damage it or the oven.
- Avoid using the Digilert 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 Digilert 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.

2 Features

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



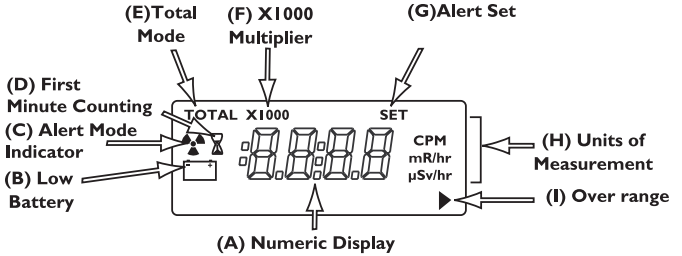
The Digilert 50 counts ionizing events and displays the results on the liquid crystal display **(LCD) (4)**. You control which unit of measurement is shown by using the mode switch.

Whenever the Digilert 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 Alert mode is turned on.
- An **hourglass (D**) appears to the left of the numeric display during the first minute the Digilert 50 is operating, to show that the reading is not yet complete.
- **TOTAL (E)** appears when the Digilert 50 is in Total mode.
- **X1000 (F)** appears when the radiation level on the display should be multiplied X1000.
- **SET (G)** appears when you are setting the alert level.
- The **unit of measurement (H)—CPM or mR/hr**—is displayed to the right of the numeric display. The European version of the Digilert 50 uses µSv/hr rather than mR/hr.
- **Over range (I)**. Refer to page 7, Maximum level.

The Switches

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

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

Off. The Digilert 50 is not operating.

Mode Switch (5)

mR/hr. The numeric display shows the current radiation level in milli-roentgens 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 total 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 total reading.

The Alert Buttons (8)

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

The Detector

The Digilert 50 uses a Geiger tube to detect radiation. Alpha and low energy beta radiation does not penetrate most solid materials, so this Geiger tube has on one end, a thin disk of mica. The screened opening at the top of the Digilert 50 is called the **window.** It allows alpha and low-energy beta and gamma radiation through so it can penetrate the mica end of the tube.

CAUTION: The mica end 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 Digilert 50.

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

The **data output port (3)** is below the audio output port. It allows you to

interface the Digilert 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

Starting the Digilert 50

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

To start the Digilert 50, set the top switch to the mode you want, and set the bottom switch to **On** or **Audio.** The Digilert 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 and the hourglass icon to show that the first minute’s reading is not yet complete. One minute after you start the Digilert 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 Digilert 50’s reading in mR/hr may not be exact.

The most immediate indicators of the radiation level are the count light, the audio beep, and the alert. Updated readings are shown every 60 seconds on the numeric display in the CPM and mR/hr modes.

Operating Ranges

The following table shows the radiation levels the Digilert 50 measures in each mode and how they are displayed. When radiation levels increase over certain preset levels, the Digilert 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 total 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 Digilert 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 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 which can be due to altitude or soil mineral content. 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 Digilert 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 Digilert 50 can sound an audible alert whenever the radiation reading reaches a certain level. The three buttons on the top end allow you to turn the 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 (1mR/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 the Alert mode, the Digilert 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 the Alert mode is active, a radiation warning symbol is shown to the left of the numeric display.

When you first start the Digilert 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 provides an 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 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 (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.

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 Digilert 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

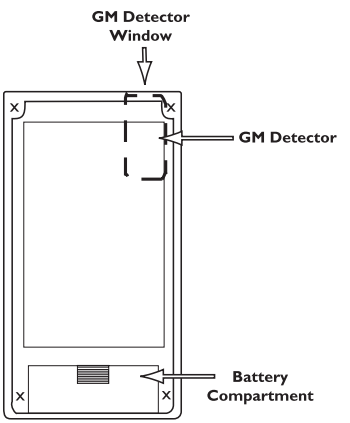
You can keep the Digilert 50 in CPM or mR/hr mode whenever you want to monitor the ambient radiation, and look at it from time to time to check for elevated readings. You can also use Alert mode to warn you if the radiation increases above the alert level.

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 end window 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 Digilert 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 Digilert 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 Digilert 50 closest to the object. The illustration to the right shows the position of the Geiger tube.



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

Troubleshooting

The Digilert 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 Cause	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 Digilert 50 with another instrument; clean the instrument with a damp cloth with mild detergent

Problem	Possible Cause	What to Check
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 Digilert 50 requires servicing, please contact your distributor or the manufacturer at the following address:

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

S.E. International, Inc.
P.O. Box 39, 436 Farm Rd.
Summertown, TN 38483-0039
Tel: 931-964-3561 Fax: 931-964-3564

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

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 Digilert 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.

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 year	Ra-226	Radium
Ra-226	alpha	1,602 years	Rn-222	Radon
Rn-222	alpha	3.8 days	Po-218	Polonium
Po-218	alpha	3 minutes	Pb-214	Lead
Pb-214	beta	26.8 minutes	Bi-214	Bismuth
Bi-214	beta	19.7 minutes	Po-214	Polonium
Po-214	alpha	164 microseconds	Pb-210	Lead
Pb-210	beta	21 years	Bi-210	Bismuth
Bi-210	beta	5 days	Po-210	Polonium
Po-210	alpha	138 days	Pb-206	Lead

Measuring Radiation

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

The Geiger tube used in the Digilert 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 Digilert 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, readings will vary from minute to minute.

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

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 Digilert 50 in CPM 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 Specifications

Detector:	Halogen-quenched Geiger-Mueller tube with mica end window. Mica window density 1.5-2.0 mg/cm^2. Side wall is .012".
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 (European version only)
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)
Outputs:	Dual miniature jack sends counts to CMOS-compatible devices, including computers, data loggers, and educational data collection systems 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; battery life is 2000 hours typical at normal background; 150 hours typical at 1mR/hr

Size:	150 x 80 x 30 mm (5.9” x 3.2” x 1.2”)
Weight:	225 grams (8 oz) including battery

Warranty

LIMITED WARRANTY

WARRANTOR: S.E. International, Inc., P.O. Box 39, 436 Farm Road, Summertown, TN 38483-0039, USA, (615) 964-3561.

ELEMENTS OF WARRANTY: S.E. International, Inc., warrants for one year all materials and craftsmanship in this product to be free from all defects with only the limitations set out below.

WARRANTY DURATION: The warranty shall terminate and be of no further effect one year after the original date of purchase of the product or at the time the product is: a) damaged or not maintained as is reasonable or necessary, b) modified, c) repaired by someone other than the warrantor for a defect or malfunction covered by this Warranty, d) contaminated with radioactive materials, or e) used in a manner or purpose for which the instrument was not intended or contrary to S.E. International, Inc.’s written instructions. This warranty does not apply to any product subjected to corrosive elements, misuse, abuse, or neglect.

STATEMENT OF REMEDY: In the event that the product does not conform to the warranty at any time while this warranty is effective, the Warrantor will repair the defect and return the instrument to you prepaid, without charge for parts or labor.

NOTE: While the product will be remedied under this warranty without charge, this warranty does not cover or provide for the reimbursement or payment of incidental or consequential damages arising from the use of or the inability to use this product. The liability of the company arising out of the supplying of this instrument, or its use, whether on warranties or otherwise, shall not in any case exceed the cost of correcting defects in the instrument, and after the said one year (90 days on the tube) period all such liability shall terminate. Any implied warranty is limited to the duration of the written warranty.

PROCEDURE FOR OBTAINING PERFORMANCE OF WARRANTY: In the event that the product does not conform to this warranty, please write or call to the address above. S.E. International, Inc. will not accept contaminated instruments for calibration or repair under warranty or otherwise.

NOTE: Before using this instrument, the user must determine the suitability of the product for his or her intended use. The user assumes all risk and liability

Calibration Database Service
For U.S. and Canada Only

For your convenience, we offer a calibration service. To be included in our Calibration Database, fill out the application included in this manual. Send it to the address listed on the application and we will enter you in the database free of charge.

Once your instrument is entered into our Calibration Database, at specified intervals, you will be sent a notice reminding you of the upcoming calibration date.

---------- Cut along dotted line ----------

CALIBRATION DATABASE APPLICATION

name	model name
company	serial no. (Inside battery compartment or rear label)
address	
City, state, zip code +4	calibrations per year (circle) 1 2 3 4
phone number	

Mail to Attn: Steve Skinner or Robbin Cramer

S.E. International, Inc., P.O. Box 39, Summertown, TN 38483-0039 or fax to (931) 964-3564