Digilert™

RADIATION ALERT®
OPERATION MANUAL
FOR
DIGILERT
NUCLEAR RADIATION MONITOR

RADIATION ALERT®
NOTICE D'EMPLOI
POUR
DIGILERT
Compteur de rayonnements ionisants

SE INTERNATIONAL

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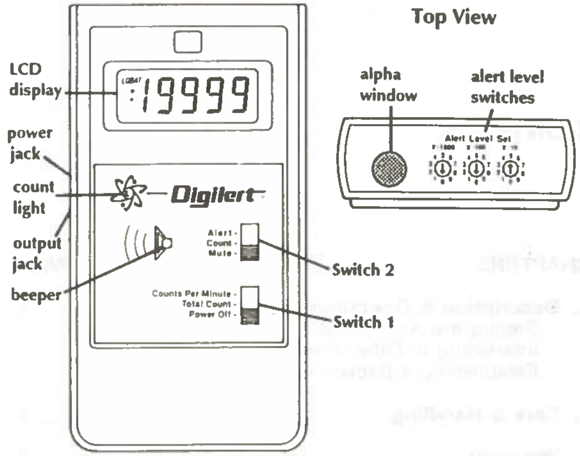
OPERATION MANUAL
FOR THE DIGILERT NUCLEAR RADIATION MONITOR

CONTENTS

This manual gives complete instructions for using the Digilert and procedures for common applications. It also gives basic information on radiation. Be sure to read this manual thoroughly so that you can gather and interpret your findings accurately.

1. DESCRIPTION & OPERATION OF YOUR DIGILERT

The Digilert measures alpha, beta, gamma, and X-ray radiation. The following illustration shows the Digilert and its features.



The Geiger tube detects ionizing events. The electronic circuit counts these events and displays the results on the **liquid crystal display (LCD)**. You control how the counts are displayed by setting the display mode. The Digilert also contains an alert mode that sounds a pulsating beep when incoming radiation exceeds an adjustable pre-set level.

The Digilert measures radiation in counts. One count is one ionizing event detected in the Geiger tube.

Before turning on your Digilert, be sure that an alkaline 9-volt battery is installed in the battery compartment in the lower rear. One battery operates the Digilert continuously for 3 to 6 months at normal radiation levels. The LCD display warns you when the battery is getting low by displaying a **LOBAT** message at the upper left of the display.

Use **Switch 1** to turn on your Digilert. Switch 1 allows you to choose either of two display modes and to turn the Digilert off and on. In the **Counts Per Minute** mode, the number of counts detected per minute is displayed on the LCD. This number is updated after each minute. During the first minute of operation in this mode, a flashing colon (:) tells you that the count is in progress. In **Total Count** mode, the LCD shows the accumulated counts, adding counts as they occur. The display can show up to 19,999 counts.

To reset the display to zero, switch from **Total Count** to **Counts Per Minute**, then back to **Total Count** or simply turn the Digilert off and on again.

When the Digilert is turned on, the **count light** will flash each time a count is detected.

Switch 2 allows you to choose any of three audio modes. If you set the switch to **Count**, the Digilert will beep at each count. The **Mute** setting turns off the beep. In the **Alert** mode, it sounds a pulsating beep if the count reaches the alert level. In **Counts Per Minute** display mode, the alert sounds when the count reaches the alert level and continues to beep until the end of that one minute period. (It sounds again the next minute if the count reaches the alert level again.) In **Total Count** mode, the alert sounds until you either change switch 1 from **Total Count** to **Counts Per Minute** or **Off**, or change switch 2 to **Count** or **Mute**.

The **alert level switches** on the top of the Digilert enable you to set and change the level at which the beeper sounds. The alert level is set to 9990 when you first receive the Digilert. See "Setting the Alert Level" in the next section for instructions on how to change this setting.

The screen at the top of the Digilert is called the **alpha window**. It allows alpha rays and low-energy beta and gamma rays to penetrate the mica end of the tube. Alpha radiation does not penetrate most solid materials. However, the Geiger tube used in the Digilert has a thin disc of mica (located on the end), which alpha rays can penetrate. If you want to measure alpha radiation or low-energy beta and gamma radiation from an object, hold it close to but not touching, the alpha window.

CAUTION: The mica end window of the Geiger tube is very fragile.

Be careful not to let anything push through the screen.

The top (and smaller) **power jack** on the side of the Digilert enables you to connect the Digilert to a power supply that you can plug into a regular wall socket. We recommend that you use the power supply (adapter) we have available upon request. It is a 9-volt DC filtered regulated power supply with a minature phone plug, tip positive. If you have a power failure while running the Digilert on AC current, the battery automatically takes over.

The lower **output jack** allows you to interface the Digilert to a computer, data logger, external alert, or other device. For more information, see "Interfacing to External Devices".

For more information on what ionizing radiation is and how the Digilert detects it, see "Ionizing Radiation".

Setting the Alert Level

The alert level is the number of counts that sets off the audible alert. The three alert switches at the top of the Digilert set the alert levels.

Use a small screwdriver to adjust the alert level switches. You can set the alert level at any multiple of 10 counts from 10 to 9990. The switch marked **x10** sets the tens value; the **x100** switch sets the hundreds value; and the **x1000** switch sets the thousands value. For example, to set the alert level to 130, set the x1000 switch to 0, the x100 switch to 1, and the x10 switch to 3.

In **Counts Per Minute** (CPM) operating mode, the alert sounds when the counts in the current minute reach the alert level. In **Total Count** mode, the alert sounds when the total reaches the pre-set alert level. Keep in mind that if you set the alert level to, for example, 50 for **Counts Per Minute** operation, and you then run the Digilert in **Total Count** mode, the alert will sound as soon as the accumulated count reaches 50.

The best alert level is one that rarely gives a false alarm, yet warns you when the radiation is higher than normal. The statistical formula outlined below shows one way to determine this level for your area in counts per minute. You can experiment with different alert levels, or use another method to decide on the best alert level for your purposes.

First, find the standard deviation, using the following steps.

1. Use the Digilert 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 value you can expect, multiply the standard deviation by three 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 3 x 4.3 to 12.8 to get 25.7. Set the Alert level at 30, the next higher level available.

Interfacing to Other Devices

You can interface the Digilert to an external device such as a data logger, computer, or warning device.

The lower output jack on the left side of the Digilert is a dual miniature jack that provides two outputs, which can be used to drive CMOS or TTL devices. They are:

Data out: This output is the tip of the plug. It provides a positive (5 volt) pulse each time the Geiger tube detects a count. You can use it to record the counts on a data logger, accumulating counter, computer, or printer. This interface makes it possible to record radiation levels over time.

Alert out: This output is the ring of the plug. It provides a positive signal whenever the current alert level setting is exceeded (even if the audio switch is set to **Mute**). The output can control devices such as a loud beeper or horn, a flashing light, or any combination of devices. It enables you to use the Digilert as an Area Monitor in a noisy location. It can also be used to signal an automatic telephone dialer to call a certain number if the alert level is exceeded.

You can use the optional interface cable to connect to the external device. It is a two-wire shielded cable with a 3.5mm dual miniature plug attached. It can be terminated to CMOS or TTL inputs. These interfaces make possible many applications, some of which require customization.

Establishing a Background Count

Normal background radiation levels vary at different locations according to altitude and other factors, such as types of minerals in the ground. Before you can interpret the readings you get on the Digilert, you must establish the normal background radiation level for your area. To do this, turn on the Digilert and set the display mode to **Counts Per Minute**. (You can use any of the **Mute, Count,** or **Alert** audio modes.) Notice the count may change quite a bit from minute to minute; it may be 8 one minute and 16 the next. You can quickly determine the average in either of two ways:

1. Note the counts for about ten minutes and average them.
2. Change to **Total Count** and wait exactly ten minutes. Note the reading and divide it by ten for the average counts per minute.

A ten minute average count is moderately accurate. You can repeat it several times and see how close the averages are. To establish a very accurate average, use the procedure for getting a 12-hour average described in "Checking for Small Increases".

2. CARE & HANDLING

To keep your Digilert in good condition, handle it with care as you would any electronic instrument. Observe the following precautions:

1. Do not leave the Digilert in temperatures over 100°F/37.8°C or in direct sunlight for extended periods of time (e.g., on the dashboard in a closed car).
2. Do not contaminate the Digilert by touching it to radioactive materials.
3. Do not put the Digilert in a microwave oven. It cannot measure microwaves, and you may damage it or the oven.
4. The mica end window of the GM tube can be easily damaged if struck directly or dropped. Do not insert any pointed object through the alpha screen.
5. Avoid exposing the Digilert to liquids, moisture, and corrosive gases.
6. This instrument may be sensitive to radio frequency, microwave, electrostatic, and magnetic fields, and may not operate properly in such fields.

NOTE: You can send the Digilert through an airport security X-ray machine. However, if it's on and set to **Alert**, it will go off.

3. WARRANTY

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 connected with such use.

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 and LCD display, which are warranted for 90 days. The battery is not included in the warranty. S.E. International, Inc. 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. S.E. International, Inc. is not responsible for incidental or consequential damages arising from the use of this instrument.

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

4. RADIATION AND ITS MEASUREMENT

This chapter explains what radiation is, and how it is measured. This information is very helpful in understanding how the Digilert works and in interpreting your readings.

This chapter is just an introduction to these subjects. Many books are available. We encourage anyone concerned to further educate themselves as much as possible.

Ionizing Radiation

Ionizing radiation is radiation that changes the structure of individual atoms by ionizing them. Ionization is the process by which electrically neutral atoms are changed to positively and negatively charged ions (atoms and subatomic particles). 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 exists in the ground. The most common of these is uranium.

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 (also called photons) are electromagnetic radiation of the same nature as light and radio waves but at an extremely short wavelength, less than 0.1 billionths of a centimeter. 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. They also act on photographic film as light does. These two properties have made X-rays a powerful tool in the medical and physical sciences.

Gamma rays are naturally occurring radiation that is almost identical to X-rays. A gamma ray is the photon emitted when an electron is added to the nucleus of an atom. Gamma rays generally have a shorter wavelength than X- rays.

Beta rays also occur in nature. A beta ray is actually a particle, an electron emitted from an atom. It has more mass and less energy than a gamma ray, so it doesn't penetrate matter as far as gamma or X-rays.

Alpha rays are another naturally occuring form of ionizing radiation. An alpha ray is a particle that consists of two protons and two neutrons, the same as the nucleus of a helium atom. It is emitted when an atom decays.

When an atom emits an alpha, beta, or gamma ray, it becomes a different type of atom. This process is called decay. Radioactive substances may go through several stages of decay before they change into stable form.

An element may have several forms, called isotopes, that differ in the number of neutrons and/or electrons in the atom. A radioisotope is a radioactive form of an element. Each radioisotope has a half-life, which is the time required for half of a quantity of the material to decay.

For example, Thorium 234 (the isotope of thorium with the atomic weight of 234) has a half-life of 24 days. If you start with one gram of Thorium 234, after 24 days, ½ gram will have decayed into Proactinium 234 by emitting beta rays.

Theoretically, the thorium takes an infinite time to decay completely, because for each succeeding half-life, only half the remaining material decays. After seven times the half-life, 99% of the original material has decayed, and after ten times the half-life, 99.9% has decayed.

The isotope produced when a radioisotope decays may also be radioactive. In this example, Thorium 234 and Proactinium 234 are part of the radioactive decay chain for Uranium 238. Uranium and its decay products are the most common radioactive materials in the ground. The following chart shows the complete decay chain for Uranium 238, which ends with a stable isotope of lead. Notice the half-life of the radioisotopes in the chain range from 164 microseconds to 4.5 billion years.

Isotope	Emits	Half-life	Product
U238	alpha	4.5 billion years	Th234 Thorium
Th234	beta	24.1 days	Pa234 Proactinium
Pa234	beta	1.17 minutes	U234 Uranium
U234	alpha	250,000 year	Th230 Thorium
Th230	alpha	80,000 years	Ra226 Radium
Ra226	alpha	1,602 years	Rn222 Radon
Rn222	alpha	3.8 days	Po218 Polonium
Po218	alpha	3 minutes	Pb214 Lead
Pb214	beta	26.8 minutes	Bi214 Bismuth
Bi214	beta	19.7 minutes	Po214 Polonium
Po214	alpha	164 microseconds	Pb210 Lead
Pb210	beta	21 years	Bi210 Bismuth
Bi210	beta	5 days	Po210 Polonium
Po210	alpha	138 days	Pb206 Lead

All isotopes in the uranium decay chain are solids except for radon, a gas. After radon is produced, it migrates through the ground to enter the atmosphere.

The Detector

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.

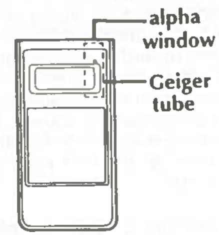
The Digilert uses a Geiger tube, which is a commonly used method of detecting ionizing radiation. The tube consists of an anode and a cathode (positive and negative electrodes) separated with a mixture of argon, neon, and either chlorine or bromine gases.

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 electronically processes these pulses and displays a count on its display.

Checking for Radiation

If you want to check an object, just put the Digilert next to it. If the count is higher than normal, the object is radioactive. When checking for alpha radiation, be sure to check using the alpha window. If the object is radioactive, get readings at six inches, one foot, and two feet from it. Usually the radiation drops off sharply at a short distance. The reading at any distance from the object indicates the radiation exposure you get at that distance.

The illustration at the right shows the position of the Geiger tube. When you are not using the alpha window, hold the Digilert 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 closest to the object.



The illustration at the right shows the position of the Geiger tube. When you are not using the alpha window, hold the Digilert 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 closest to the object.

Chapter 5, "Applications", gives suggestions and techniques for specific checks you can make.

Determining the Radiation Dose

Several different units are used to measure radiation exposure and dosage. The most commonly used units are the rad and the rem.

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 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.

A **rem** is the dosage received from exposure to a rad. It is the number of rads multiplied by the Relative Biological Effectiveness (RBE) of the particular source of radiation. The rem and the **millirem** (one thousandth of a rem) are the most commonly used measurement units of radiation dose in the U.S.

Radiation is often measured in a dose rate, generally in millirems per hour. For example, if a person is exposed to radiation at 10 millirems per hour for one hour, his or her dose is 10 millirems; if the person is exposed for half an hour, the dose is 5 millirems.

The average dose per person from background radiation was until recently thought to be about 100 millirems per year. Recently, the National Council on Radiation Protection and Measurement (NCRP) released their Report No. 93, "Ionizing Radiation Exposure of the Population of the United States". This report takes into account sources such as radon exposure and occupational exposure, and sets the average at 360 millirems whole body dose per year. The occupational exposure limit in the U.S. is 1¼ rems (1250 millirems) per quarter (5 rems per year) whole body dose under normal conditions.

Different radioactive materials produce different types (and combinations of types) of rays. Also, the energy levels and types of radiation differ in different radioisotopes. Thus, the counts recorded in a Geiger tube represent different levels of radiation from different materials. Geiger counters that measure radiation in Roentgens or rads are calibrated for a specific type of radioactive source; for example, Cesium 137. The reading is most accurate for that isotope; if the radiation is coming from a different type of material, the reading is not as accurate.

Converting Counts to mR/hr and μSv/hr

The counts per minute reading that the Digilert gives does not give you a measurement in rads, Roentgens, or rems; the actual exposure and dosage produced by a specific number of counts depends on the isotopes that are producing the radiation. If you want to convert the Digilert counts per minute reading to the dosage in millirems per hour, you need to know the isotopes that are producing the radiation. If you have access to calibrated sources of other isotopes, you can determine the appropriate conversion factor by using the procedures below.

The Geiger tube in the Digilert has been calibrated for Cobalt 60 and Cesium 137. To convert counts to milliRoentgens per hour (mR/hr) for Cobalt 60, divide the counts per minute by 958. For Cesium 137, divide the counts per minute by 982. For example, if you measure 1675 CPM and you know the source is Cesium 137, divide 1675 by 982. The answer is about 1.7 milliRoentgens per hour.

To convert the counts in the example given above to microSieverts per hour (μSv/hr), remember that 1 mR/hr = 10 μSv/hr. Therefore, divide the number of counts by 98.2 CPM (Cesium 137) or multiply your mR/hr reading by 10. Thus, 1675 CPM = 17 μSv/hr.

5. APPLICATIONS

Checking for Small Increases

To check for small differences in radiation (for example, between outdoors and indoors), use **Total Count** mode. Keep the Digilert operating continuously in **Total Count** and take readings every 12 hours; for example, at 7 AM and 7 PM. After you take each 12-hour reading, switch from **Total Count** to **Counts Per Minute**, then back to **Total Count** to reset the display to zero.

Find the total count for a 12-hour period in each location. You can use 12-hour counts to check for small differences over time.

Take two 12-hour measurements outdoors. For the first measurement, place the Digilert on a safe place on the ground in an unpaved area. (Make sure it does not get wet, overheated, or frozen.) For the second measurement, place it about 4-6 feet above the ground. With this procedure, it is possible to detect alpha radiation from the earth that rapidly dissipates in air.

To compare radiation levels from 12-hour counts, it's best to convert the total counts to counts per minute. You can reliably detect differences as low as one count per minute by comparing 12-hour counts.

High Radiation Levels

If your Digilert shows abnormally high radiation levels and you are not measuring a known source of radiation, try to confirm your readings. Public Health Departments, hospital health physics or nuclear medicine departments, Civil Defense offices, and police or fire departments may have monitoring equipment with which they can check your finding.

You can also determine if the radiation source is localized or if the increase is general. A localized source could be, for example, an item you are checking, an excavation that has uncovered radioactive deposits, or a truck that contains radioactive materials.

The radiation level from a localized source decreases according to the inverse square law. If you move to twice the distance from the source, the radiation drops by a factor of four. If you move and the radiation level goes up by a factor of four, your distance from the source is half of that where you started. If you find a strong localized source, get as far away from it as you can and notify the appropriate authorities.

Make every effort to minimize your radiation exposure. If you can leave the area, do so as soon as possible. Use the Digilert to check your clothing and yourself for contamination. If you find it, dispose of your clothing and shower thoroughly to remove any radioactive particles. With a general source of radiation, you may not be able to leave the area to reduce your exposure. Be aware that radiation from airborne radioactive particles is less in an enclosed building.

The Digilert display shows up to 19,999 counts. If you measure a higher count, the display still reads 19999. To obtain a relative indication of the dose rate, put the Digilert in **Total Count** mode, use a watch to determine the length of time from 0 to 19,999 counts, and convert the reading to counts per minute.

At extremely high radiation levels (above 1 Roentgen per hour), Geiger tubes can become "saturated". Saturation can cause false low readings. The Digilert contains special anti-saturation circuitry. Still, it is advisable to avoid high radiation levels and not to depend on any single instrument in such a hazardous situation. A 125 milliRoentgen per hour radiation level (with a Cesium 137 source) would be about 120,000 counts per minute on the Digilert. In **Total Count** mode, 19,999 counts would be reached in about ten seconds.

Checking for X-ray Leakage

If you are working in a medical or dental office, lab or an industrial plant with an X-ray machine, you can detect radiation that leaks through the shielding to any area.

Note: Due to the powerful intensity and short duration of X-rays from X-ray machines, specialized equipment is necessary to get calibrated measurements. The Digilert cannot give an accurate qualitative or quantitative measurement, but it can indicate reliably whether leakage occurs.

To determine if there is X-ray leakage to a specific location such as a technicians station near an X-ray machine, use the following procedure. To be sure, repeat the test at several locations. X-ray equipment should be operated by a trained operator who understands safety procedures and health risks.

1. Turn the Digilert on in **Total Count** mode and set the audio switch to **Count**. Place it in the location you want to check.
2. Move to a safe shielded location. Use a lead apron and other shielding, if necessary.
3. Activate the X-ray machine for a short period of time. 400 milliseconds is generally a good period.
4. You will hear the Digilert beep rapidly if it is detecting X-rays.

6. SPECIFICATIONS

Detector: Halogen quenched Geiger-Meuller tube with mica end window (LND712). Areal density of end window is 1.5-2.0 mg/cm². Sidewall is .012" #446 stainless steel.

Display: 0.4 inch digit liquid crystal display, 4-½ digit.

Range: 0-19999 accumulated counts or 0-19999 counts per minute. (approx. 0-20 mR/hr)

Calibration: Cesium 137: 982 cpm per mR/hr
Cobalt 60: 958 cpm per mR/hr

Alert: Pulsating beeper sounds the alert. Alert level is adjustable in 10-count increments, 10-9990.

Count Light: Red LED flashes with each count.

Beeper: Can be set by switch to either Count, Alert, or Mute. Output soundpressure level is 75 dB at 12 inches (3 kHz).

Outputs: Dual miniature jack drives CMOS or TTL devices:
1) tip: counts to computer or data logger
2) ring: alert to external warning device

Power: 9-volt alkaline battery gives 3-6 months continuous use at normal background level; jack provided for optional AC adapter.

Temp. Range: 0° to 50°C (32° to 122°F).

Size: 150 x 80 x 30 mm (5.9 x 3.2 x 1.2 inches)

Weight: 270 grams (9.5 oz.) including battery.

These specifications are subject to change without notice.