RADIATION MONITOR

840007 & 840026

INSTRUCTION MANUAL

SPER SCIENTIFIC

Environmental Measurement Instruments

TABLE OF CONTENTS

INTRODUCTION

This manual contains valuable information about the nature of ionizing radiation that should be understood by the user so that accurate measurements can be made. Information on the care of your Geiger counter is also included. If the following instructions are followed, your radiation monitor will give you many years of reliable service.

The radiation meters are very sensitive pieces of equipment. Although housed in a high-impact case, the Geiger-Mueller tube that senses radiation is fragile. If the unit is dropped, the G-M tube may break. Exposure of the unit above 40°C (100°F) may also cause the G-M tube to stop functioning. The electronic circuitry is sensitive to high humidity (over 90% R.H.).

CAUTION

DO NOT put the unit in a very hot place (such as a car's glove box, especially on a summer day).

DO NOT allow the unit to get wet. However, if this should happen, clean it with a towel and allow unit to air-dry for several days (do not place in an oven or microwave).

DO NOT open the unit (except for battery replacement). There are no adjustments inside for the 840007 that can be made by the user, since the unit is calibrated at the factory. For the 840026, see instructions on page 5.

BATTERY REPLACEMENT

The unit is powered by a 9-volt battery. With the on button activated, the LED should be brightly lit. When the LED is no longer bright or when the LED dims in the presence of a radiation source, replace battery. To replace the battery:

1. Slide the plastic door off the unit located in the back.

2. Carefully replace the battery. DO NOT reach into the unit through the battery compartment while unit is on. G-M tube activation voltage is over 200 VDC.

3. Replace plastic door.

4. For extended operation and infrequent battery replacement, use an alkaline battery.

OPERATION

The radiation monitor only operates while the push button on the face of the unit is depressed. This feature makes the operation very simple and conserves battery power. The unit is designed to be held in the right hand, with the thumb over the pushbutton (see Figures 1 and 2). The LED just above the pushbutton indicates that the unit is on and will give an indication of battery condition.

When the unit is turned on, a faint buzz may be audible in a quiet room. This is normal and is caused by the transformer that powers the G-M tube.

In most parts of the world, background radiation will cause the speaker to click at random intervals, about one click every few seconds. In areas where large deposits of natural radioactive minerals are found, or in an area that has been contaminated with radioactive materials, the speaker will click more frequently. This is called the "background level." It should be taken into account when making measurements on specific objects.

Since the incidence of clicks from radioactive sources is random, several clicks can be heard in rapid succession, while on other occasions several seconds may elapse between clicks. This is normal. Averaged over a period of time, the click rate should remain relatively constant. A reasonable average time should be at least two minutes or more.

The Geiger-Mueller tube is located behind the slots in the upper edge of the case. The surface of the tube is very thin (0.004"). This allows beta radiation to penetrate and to be detected with greater efficiency. (Beta rays and other types of radiation will be discussed in the next section). This thin surface is fragile and poking sharp objects through the slots will damage the tube.

Your Geiger Counter is designed to be sensitive to:

1. Gamma radiation (which includes X-rays).

2. Beta radiation.

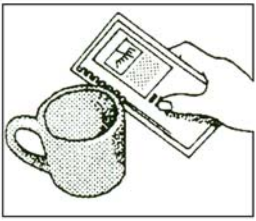

FIG. 1

Gamma radiation and X-rays can penetrate the plastic case with comparative ease.

Beta radiation can most efficiently enter the case through the slots. Although Beta radiation is easily detected, it is difficult to measure accurately. Therefore, when a radioactive object is being searched for Beta radiation, the open slots in the case should be positioned in such a way that they are exposed to the object (see Figure 1).

If the unit shows a significantly higher click rate in this position, you can be reasonably certain the object is giving off Beta radiation.

Now position the unit as shown in Figure 2. In this position, where radiation cannot pass directly through the slots (Beta radiation travels in straight lines for the most part) only gamma and X-ray radiation from the object will be detected.

THIS IS THE POSITION IN WHICH TO HOLD THE GEIGER COUNTER TO TAKE READINGS. It is important to understand this, for misleadingly high meter readings can result from allowing Beta rays to be measured with the gamma rays. The meter scale is calibrated for gamma radiation.

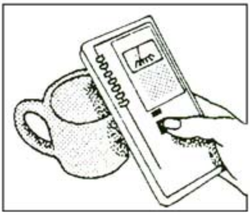

FIG. 2

READINGS

There are two Sper Scientific Radiation Monitor models:

840007 - 0.1 to 10mR/hr
840026 - 0 to 100mR/hr

All units are tested at the factory using gamma radiation. The radioactive gamma source used in the factory is Cesium-137 that has been Beta shielded with .062" of Aluminum, and measuring radioisotopes other than Cesium-137 introduces some error. The error caused by this is usually very little. Note that in the case of X-rays, the unit is very sensitive and subsequently meter readings should be divided by about 5.

The 840026 was calibrated. For how often you have to calibrate your unit, check with your local NRC. However, you must calibrate after each repair or change of G-M tube. Since the 840026 radiation monitor has an oscillator, it can be readily adjusted/calibrated by turning the screw on the oscillator with a small screwdriver in the desired direction: turning clockwise to decrease the reading; counter clockwise to increase. This calibration should be done at a licensed laboratory.

In addition to the analog meter, a special extended range has been designed into the 840007 unit. At radiation levels that are in excess of the meter scale, the unit will emit beeps, at a rate that increases as the radiation level increases. Although this range is not as accurate as the displayed range, beeping will begin approximately at 15mR/hr. A continuous beep occurs approximately at 20mR/hr. These built-in ranges greatly simplify operation and allow reasonably quick and accurate measurements to be made.

The meter is not intended to indicate levels below 0.1 mR/hr., therefore, readings taken below this level should be considered extremely crude. However, such low level measurements can be made by simply counting the clicks over a period of time, much like taking a person's pulse, and expressing the result as clicks (or counts) per minute. 0.1 mR/hr, on the meter corresponds to about 330 counts per minute.

INTERPRETING READINGS

Health physics, the field that pertains to radiation and its effects on man, is very complex, and theories and conclusions are constantly being updated as information becomes available. Data from occupational exposure, animal studies, and events like Hiroshima and Nagasaki have fairly well established the maximum safe exposure limits for man. Whether low level radiation causes cancer and birth defects is still being debated. Delayed effect, which could take years to develop, is difficult to study, and therefore, there are no well-defined lower limits on ionizing radiation. Two publications entitled "Hormesis with Ionizing Radiation," 1980 and "Radiation Hormesis," 1991 (CRC Press, Boca Raton) present over one thousand examples of statistically valid data showing no physiological harm in vertebrates from whole body exposures to low dose radiation (<20mGy/y).

As previously mentioned in the section on operation, the units mR/hr (milli-Roentgen per hour, or 1/1000th of a Roentgen per hour) pertain only to gamma radiation. Often other units of measurement similar to mR/hr are used. The term "REM" (Roentgen Equivalent Man) includes the affects of beta, alpha and neutron radiation. Measurement in REMs is more complete as radiation affects man, but such measurements are a complicated combination of many measurements each made with specialized detectors.

It is important to note that the field intensity from a radioactive object decreases very quickly with distance.

If the object is very small, increasing the distance from the object by a factor of two decreases the radiation level by a factor of four. This is called a square law situation, which demonstrates the dependence of proximity on dose for small radioactive sources. Larger sources, such as a large deposit of radioactive minerals, will show much less of this effect. In trying to estimate the danger of radioactive materials, it is important to take into account many aspects of the situation. For instance, the radiation level at the face of a radium-dial watch may be 3mR/hr, but the measurement taken from the back of the watch may be 0.3mR/hr.

Another interesting point concerns the energy of the radiation. Geiger Counters will register one click whenever they detect a ray or particle of radiation hitting them. These tiny high speed bundles of energy are like short bursts of light. Some are extremely energetic, while others are not. Geiger Counters cannot determine the energy of the impinging ray, they only detect its presence. Sper Scientific models 840007 and 840026, detect Beta and gamma radiation starting at approximately 30KeV and up to 1.5 MeV.

The opposite is the case for cosmic rays, which have enormous energy — some millions of times more energetic than anything found here on earth. The compensation figure for radiation of this type is difficult to estimate, due to the extreme range of energies that have been measured.

RADIATION — WHAT IS IT?

Nuclear physics is a very complex field, however, the basic principles can be simply explained.

All matter is composed of atoms. Atoms alone and bonded together in molecules form all the things around us, including ourselves. These atomic units are extremely small; so small, in fact, that a single grain of table salt contains approximately 1,000,000,000,000,000,000 atoms (this is not a misprint). It is impossible to see an atom, except with a sophisticated electron microscope, so many of our present day theories on the structure and composition of single atoms are based largely on the study of radiation given off from unstable (radioactive) substances.

Atoms are composed of three basic particles: protons, neutrons and electrons. Electrons are extremely light, negatively charged particles that exist as a cloud around the center, or nucleus, of the atom. Sometimes the electrons are said to occupy orbits around the nucleus. These electrons are attracted to the nucleus because of the positively charged protons that, along with the neutrons, make up the nucleus. Atoms bond together in molecules when one atom gives up or shares an electron with another atom. Chemical reactions utilize this bonding process.

In all atoms, the number of electrons (and therefore the number of negative charges) equals the number of protons (positive charges). The number of protons or electrons in an atom determines the chemical nature of the atom, and each element has its own unique number (example: hydrogen = 1, helium - 2 etc.). The number of neutrons, however, may not always be the same in every atom of a particular element. Atoms of an element with different numbers of neutrons are called isotopes. Every atom of a particular element has the same atomic number, but different isotopes of a given element have different atomic weights.

It is the variable number of neutrons in the nucleus of an atom that leads to a process called nuclear decay that causes radiation. When an atom has too many or too few neutrons in its nucleus, it will have a tendency to rearrange itself spontaneously into a new combination of particles that are more stable. In this decay process, bundles of excess energy are shot out of the nucleus in one of a number of ways.

> When the neutrons are excessive, a neutron can convert itself to a proton and shoot out an electron at very high speed, known as beta radiation.
>
> A proton may be converted to a neutron to cause an unusual particle called a positron to be ejected from the nucleus.
>
> In still another process, the nucleus, in a vain atempt to stabilize itself, kicks out two protons and two neutrons all together as one particle, called an alpha particle.

The energy released in each decay can be enormous. This decay process is utilized in atomic reactors and bombs. When certain very heavy isotopes of uranium or plutonium (or several other isotopes) decay, they may split apart. This process is called fission. In fission, the entire nucleus splits apart, causing two new atoms and releasing a very large amount of energy. This process is not very predictable, for the nucleus can split in many ways, yielding a wide variety of new atoms and even some free neutrons. The free neutrons, when released, can be absorbed by other fuel atoms, causing them, in turn, to fission -- leading to a continuous or (if not controlled) explosive chain reaction. Due to the wide range of new atoms produced in the fission process, many of the daughter products are not stable and will, in turn, decay themselves, leading to hazardous nuclear waste and fallout.

In all of the above processes, another kind of radiation, gamma, is almost always released. Unlike the particles previously mentioned, gamma radiation consists of tiny, discrete bundles of energy called quanta. Light, X-rays and gamma rays can all be described as quanta, the difference being the total energy packed into each bundle.

In nuclear decay some energy in the unstable nucleus is dissipated to its surroundings in the form of heat and radiation in the instant that it decays. The nucleus may remain in its unstable state for billions of years, and then suddenly decay spontaneously. The time required for half of the atoms of a particular isotope to decay is called the half-life of that isotope. For an isotope with a half-life of 1 year, the pure isotope substance would be only 50% pure after one year, half of the original atoms having decayed into some other substance. After another year, 25% of the original material would remain, and so on. Natural radioactive materials in our world are only those with very, very long half-lives. Uranium-238, for example, has a half-life of 4 billion years, and exists today only because not enough time has elapsed since its creation for it to decay away to negligible levels. It is thought that the universe was created from a huge mass of subatomic particles and energy — the Big Bang Theory.

Of the elements and their isotopes that constitute our planet, the vast majority are quite stable, the result of billions of years of nuclear decay. The amount of radiation given off from natural radioactive minerals in the earth's crust is a major constituent of background radiation. For the most part, it is quite low, due to the long time required for the remaining radioisotopes to decay. In atomic reactions (either natural or forced by man) the decay process is sped up by the effect of neutrons given off in the fission process interacting with more unstable isotopes to cause immediate decay. While this allows the energy of the isotope to be harvested in a conveniently short time, the unstable decay products produced generally have short half-lives, on the order of seconds to centuries, and are very radioactive. As a result of this process, considerable larger quantities of short half-life (high decay rate) isotopes become a part of the world we live in. This is the basis for the controversy and concerns on the subject of nuclear power generation, waste disposal, and nuclear weapons.

INTERACTION OF RADIATION WITH MATTER

The particles and photons that result from nuclear decay carry most of the energy released from the original unstable nucleus. The value of this energy is expressed in electron Volts, or eV. The energy of beta and alpha rays is invested in the particles' speed. A typical beta particle from Cesium-137 has an energy of about 500,000 eV, and a speed that approaches that of light. Beta energies can cover a wide range, and many radioisotopes are known to emit betas at energies in excess of 10 million eV. The penetration range of typical beta particles is only a few millimeters in human skin.

Alpha particles have even shorter penetration ranges than beta particles. Typical alpha energies are on the order of 5 million eV, with ranges so short that they are extremely difficult to measure. Alphas are stopped by a ~nin sheet of paper, and in air only travel a few inches at most before coming to a stop. Therefore, alpha particles cannot be detected without being in close contact with the source, and even then only the alphas coming from the surface of the source can be detected. Alphas generated within the source are absorbed before reaching the surface. Due to short range, alpha particles are not a serious health hazard unless they are emitted from within the body when their high energy, in close contact with sensitive living tissue, is an extreme hazard. Fortunately, almost all alpha-emitting substances also emit gamma rays, allowing for their detection.

Neutrons, having no net charge, do not interact with matter as easily as other particles, and can drift through great thickness of material without incident. A free neutron, drifting through space, will decay in an average of 11.7 minutes, yielding a proton and an electron (beta ray). The neutron can also combine with the nucleus of an atom, if its path carries it close enough. When a neutron is absorbed into a nucleus, it is saved from its ultimate fate (decay), but may render the nucleus unstable. This absorption process is used in medicine and industry, to create radioactive elements from non-radioactive ones. Detecting neutrons is specialized and beyond the scope of typical Geiger counters, but most possible neutron sources also emit gamma and beta radiation, affording detection of the source.

The highly energetic X-ray and gamma rays lose their energy as they penetrate matter. X-rays have an energy of up to about 200,000 eV, compared to gamma radiation which can be as energetic as several million eV. One million eV gamma radiation can penetrate an inch of steel. Gamma and X-ray radiation are by far the most penetrating of all common types, and are only effectively absorbed by large amounts of heavy, dense material of high atomic number, such as lead.

SPECIFICATIONS

model	Calibration Radiation	Range	Typical Accuracy	Min/Max Detection Energy
840007	Gamma*	0~10 mR/hr	+20%	30 KeV ~ 1.5 MeV
840026	Gamma*	0~100 mR/hr	+15%	30KeV ~ 1.SMeV

*(Cesium 137)
1mR/hr=10μS/hr

LIMITED WARRANTY

The 840007 and 840026 Geiger counters are warranted for 5 years on electronics and 1 year for G-M tube from the date of purchase. If a unit fails to function properly within the warranty period, Sper Scientific will repair or replace the unit, at its option. This warranty does not cover any damage to the unit as a result of misuse, accident or repair by unauthorized personnel. Sper Scientific reserves the right to make such determination on the basis of factory inspection. All products returned for service must be shipped prepaid.

REPAIR CHARGES

Replacement of G-M tube	$80.00
Replacement of circuit board	$120.00

At time of repair, the monitor is recalibrated at no additional charge.

NOTICE

Sper Scientific believes the Geiger Counter to be accurate within reasonable standards of acceptance, and includes instructions that, if followed, will yield accurate measurements. Manufacturer assumes no liability for damages, consequential or otherwise that may arise from the use of the Geiger counter by any person, under any circumstances. This Geiger counter is sensitive to gamma, beta and X-ray radiation, but not necessarily to extremely low energy forms, or alpha, neutron or microwave radiation. Do not open Geiger counter or otherwise tamper with or attempt to service it.

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Returned unit must be accompanied by a description of the problem and your return address. Register your product online at www.sperwarranty.com within 10 days.