INSTRUCTION MANUAL
for
RDX Nuclear
DX-1
and
DX-2
Radiation Monitors
(Manufactured Since 1982)

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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. For additional information please visit **www.sensafe.com/dx1.php**.

The RDX family of radiation detection devices are ideal for Homeland Security and detecting environmental/industrial contamination including the radioactive isotopes released by nuclear power plants such as Iodine-131 and Cesium-137. The DX-1 and DX-2 instruments are very delicate radiation detectors. Although housed in a high-impact case, the Geiger-Müller (G-M) tube that senses radiation is fragile. If the unit is dropped, the G-M tube may break. Exposure of the unit above 50° C (122° F) may also cause the G-M tube to stop functioning. The electronic circuitry may stop operating temporarily when unit is exposed 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 dry out for several days in a dry place (not an oven).

DO NOT open the unit (except for battery replacement).There are no adjustments inside for the DX-1 that can be made by the user, since the unit is calibrated at the factory with special equipment. For the DX-2, see instructions on page 5.

Battery Replacement

The unit is powered by a 9-volt battery, and any 9-volt battery will work. When an 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, located on the back, to open.
2. Carefully replace the battery.

DO NOT put fingers into the unit through the battery compartment while unit is on (G-M tube activation voltage is over 200 VDC).

3. Slide plastic door closed.

Operation

The radiation monitor only operates while the ON button on the face of the unit is pressed down and held. This feature makes operation very simple and conserves battery power. The unit is designed to be held in the right hand with the thumb on the ON button (see Figures 1 and 2). The LED just above the ON button indicates that the unit is on and gives an indication of battery condition. When the LED becomes dim or does not light, a new battery is required.

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

In most parts of the world, background radiation will cause the speaker to click at random intervals, about one click per 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.

When it is desirable to detect low levels of radiation or to identify subtle changes in radioactivity, follow this suggestion. This is very beneficial when you want to detect any radiation change in your immediate environment. This procedure can be used to determine if a release of radiation from a nuclear power plant has occurred. First you need to determine the normal background radioactivity in your location by determining the number of Count-Per-Minute (CPM). Time a one minute (use clock with second hand) time period and count the number of clicks your Geiger Counter makes during the one minute. Record the number as CPM. Repeat this several times and by averaging the CPM you will determine the background CPM for your location. Now repeat this procedure for a different area or item that you suspect of being contaminated with radio nucleotides. As an example if the background CPM averaged 4 CPM and the suspected contaminated area averages 14 CPM, then the contamination level for the suspect area is about 3 times the normal Radiation environment. When you collect the CPM levels remember that several things around you can influence the natural and normal radiation background of your environment.

Elevation above sea level is one consideration, since higher elevations will have higher radiation background due to cosmic radiation from outer space. Another consideration is the soil composition in your location. Radon gas and natural radio nucleotide in the soil can significantly influence the background CPM.

Since the incidence of clicks from radioactive sources is random, several clicks will be heard in rapid succession, while on other occasions several seconds may elapse between clicks. This is normal. Averaged over a 1 minute period, the click rate should remain relatively constant.

The Gold Standard Geiger-Müller tube is located behind the slots in the upper edge of the case. The surface of the tube is very thin (3mm). 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 could break the G-M tube.

Your Geiger counter is designed to be sensitive to:
1. Gamma radiation (Which includes X-rays).
2. Beta radiation.

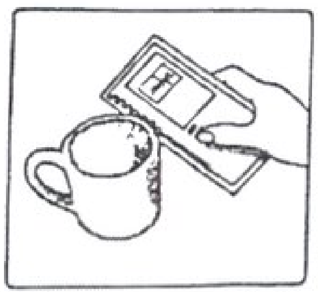

FIG.1

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

Beta radiation can most efficiently enter the case through the open slots. Although Beta radiation is easily detected, it is difficult to measure accurately. Therefore, when a radioactive object (such as a "Fiesta" ceramic cup) 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 Fig. 1).

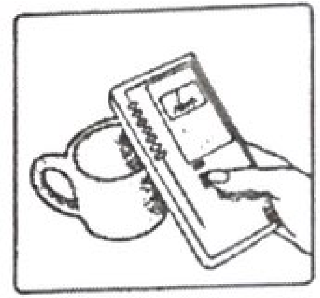

FIG.2

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 Fig. 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 only the gamma readings. It is important to understand this, for higher meter readings will result from allowing both Beta and gamma radiation to be measured (as done in Fig. 1). The meter scale is calibrated by using gamma radiation only.

Readings

All units are calibrated using gamma radiation levels. The radioactive gamma source used in the factory is Cesium-137 that has been Beta shielded with .062" of Aluminum, and measuring all radioisotopes (as would usually be the case) introduces some amount of error. The error caused by this is usually very little. Note that in the case of X-rays, the unit will be more sensitive and subsequently meter readings should be divided by about 4.

All RDX instruments have been calibrated in compliance with NRC (US Nuclear Regulatory Commission) rules and regulations, title 10, Chap. 1, Code of Federal Regulations, Part 34.25. How often you recalibrate your unit depends on your application. Recalibration is neccessary after replacement of the G-M tube.

In addition to the analog display, a special logarithmic scale has been designed into the DX-1/DX-2. At radiation levels that are in excess of the analog scale, the DX-1 will emit beeps at a rate that increases as the radiation level increases above 10mR/hr. Although this range is not as accurate as the meter, beeping will begin approximately at 10mR/hr. A continuous beep occurs approximately at 17mR/hr. These features greatly simplify operation and allow quick measurements to be made of the radiation environment that you are in.

The analog display does not indicate levels below 0.1mR/hr. However, very 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 approximately 200 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 the whole body exposures to low dose radiation (<60mR/year or 0.01mR/hour).

As previously mentioned in the section on operation, the units mR/hr (milli-Rem 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 detector.

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 (common in the 1930's) 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 the G-M tube. 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.

The opposite is true for cosmic rays (easily detected by DX-1/DX-2 in an airplane above 5,000 feet) 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 cosmic ray energies.

Radiation — What is it?

Nuclear physics is a very complex field, however, the basic principle 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 a number of ways. Examples include:

1. 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.

2. A proton may be converted to a neutron to cause an unusual particle called a positron to be ejected from the nucleus.

3. In still another process, the nucleus, in a vain attempt 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 1/2 billion years, and exists today only because not enough time has elapsed since its creation for it to decay away to negligible levels.

Scientists believe that the universe was created from a huge mass of sub-atomic 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, its 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-live (high decay rate) isotopes, such as Iodine-125, Iodine-131, and Cesium-137, 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 beta particlest 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 thin 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. Because of this, alpha particles are not a serious health hazard unless they are emitted

from within the body. Fortunately, almost all alpha-emitting substances also emit gamma rays, which allows for their detection using the RDX units.

Neutrons are used in medicine and industry to create radioactive elements from non-radioactive ones. Detecting neutrons is specialized and beyond the scope of the RDX units, but many neutron sources also emit gamma and beta radiation, allowing detection of the source by the RDX units.

Instrument Specifications:

Sensor: Halogen-quenched Geiger-Müller detector tube (Gold Standard) with 3mm glass wall (Density is 28mg/cm2)

Dual Scale Display: Analog logarithmic

Display Range: DX-1 0-10mR/h and 0-100μS/h
Display Range: DX-1 0-100mR/h and 0-1000μS/h

Factory Calibration Isotope: Cesium-137

Typical Accuracy: DX-1 ±20% DX-2 ±15%

Alert: Meter gives audible alarm when Radiation is above 10mR/h for DX-1 and above 50mR/h for DX-2.

Indicator light: Red LED confirms unit is operating and battery power is OK

Beeper: Chirps (clicks) for each gamma or Beta detected

Sensitivity: About 180 cpm/0.1mR/h (1μSv/h) referenced to Cs-137 (cpm is Counts Per Minute)

Dimensions: 3 1/4" X 6 3/4" X 1 1/2" thick

Weight: 216 grams (7.6 oz) including battery

Temperature Range: -10° to 50°C

Limited Warranty

The RDX family of Geiger counters are warrantied 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, the manufacturer will repair or replace that unit, at its option. This warranty may not cover any damage to the unit as a result of misuse, accident, damage during shipping, or repair by unauthorized personnel. Manufacturer reserves the right to make such determination on the basis of factory inspection. All products returned for service must be shipped prepaid. Call (803) 329-9712 ext. 200 or e-mail rdx@sensafe.com to arrange service.

Repair Charges (subject to change)

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

(At time of repair, unit is factory recalibrated at no additional charge.)

Marks on the case: Some of our customers have contacted us about small marks or "scratches" on the side and face of the plastic case of the unit. These are not scratches, tool marks, or flaws of any kind. These marks are created in the molding process and should not be deemed to be flaws or signs the unit was used. These marks do not affect the performance or durability of the unit whatsoever. We only sell new units. Again, all RDX cases have these mold marks and are created in the plastic molding process.

Notice

Manufacturer believes 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 for 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, tamper with, or attempt to service it. Return to manufacturer for all service repairs.

For other radiation basics, go to:

http://www.hps.org/publicinformation/ate/faqs/radiation.html

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