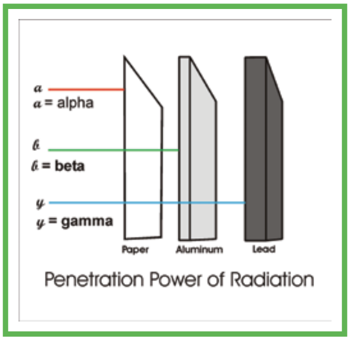
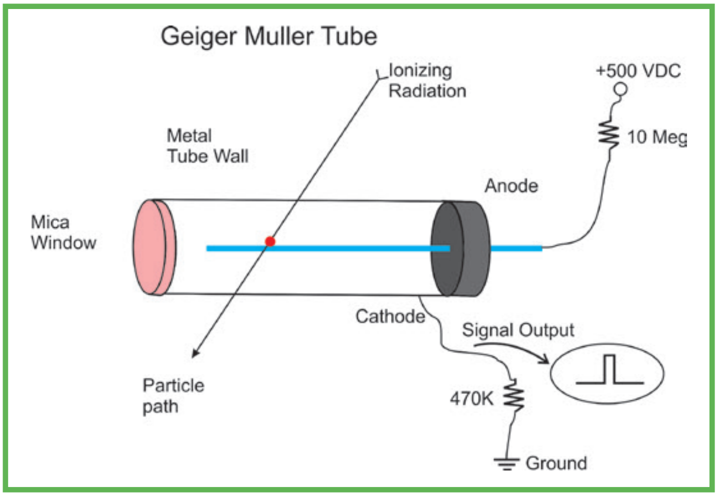
UNDERSTAND IT.





What Is Radioactivity?

Radioactivity is the spontaneous emission of energy from the nucleus of certain atoms. The most familiar radioactive material is uranium.

There are three forms of energy associated with radioactivity: alpha, beta, and gamma radiation. The classifications were originally determined according to the penetrating power of the radiation (see Figure 2). This Geiger counter can detect the three types of radiation; alpha, beta and gamma radiation.

Alpha rays are the nuclei of helium atoms — two protons and two neutrons bound together. Alpha rays have a net positive charge. Alpha particles have weak penetrating ability; a couple of inches of air or a few sheets of paper can effectively block them.

Beta rays were found to be electrons, identical to the electrons found in atoms. Beta rays have a net negative charge. Beta rays have a greater penetrating power than alpha rays and can penetrate 3mm of aluminum.

Gamma rays are high-energy photons. They have the greatest penetrating power, being able to pass through several centimeters of lead and still be detected on the other side. Thick lead is needed to attenuate gamma radiation.

Geiger Mueller Tube

Geiger Mueller tubes are simple devices that detect and measure the intensity of radioactivity. The original design by H. Geiger and E.W. Mueller in 1928 hasn't changed very much over the years. The basic sensor functions remain the same.

A cutaway drawing of a typical Geiger Mueller (GM) tube is shown in Figure 3. The wall of the GM tube is a thin metal cylinder (cathode) surrounding a center electrode (anode). The metal wall of the GM tube serves as the cathode of the GM tube. The front of the tube is a thin mica window sealed onto the metal cylinder. The thin mica window allows the passage and detection of the weak-penetrating alpha particles. The GM tube is first evacuated then filled with a mixture of neon and argon with a trace amount of a halogen gas. The exact mixtures of these gasses, as well as which halogen gas is used, are matters kept confidential by the manufacturers.

Our GM tube is put into an initial state (ready to detect a radioactive particle) by applying + 500-volt potential to the anode (center electrode) through a ten mega ohm current-limiting resistor. A 470K-ohm resistor is connected to the metal wall cathode of the tube and to ground. The top of the 470K resistor is where we see our pulse signal whenever a radioactive particle is detected.

In its initial state the GM tube has a very high resistance. However, when a radioactive particle passes through the GM tube, it ionizes the gas molecules in its path and creates a momentary conductive path in the gas. This is analogous to the vapor trail left in a cloud chamber by a particle. In the GM tube, the electron liberated from the atom by the particle and the positive ionized atom both move rapidly towards the high-potential electrodes of the GM tube. In doing so, they collide with and ionize other gas atoms, creating a momentary avalanche of ionized gas molecules. And these ionized molecules create a small conduction path, allowing a momentary pulse of electric current to pass through the tube allowing us to detect the particle.

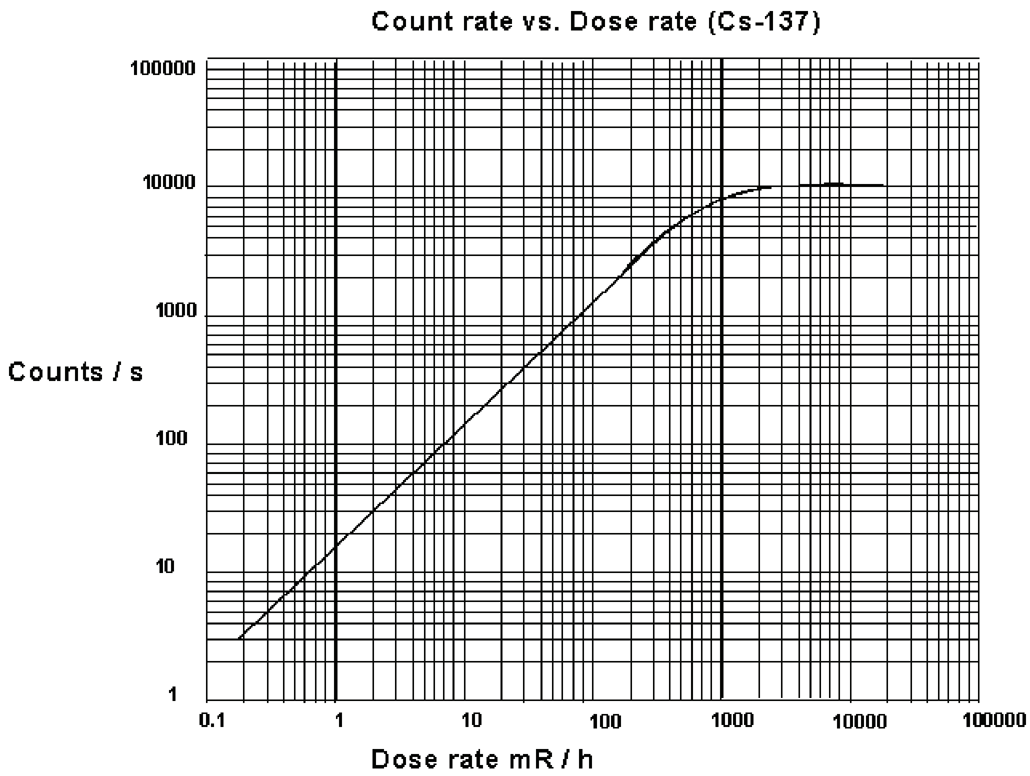
This momentary pulse of current appears as a small voltage pulse across the 470K-ohm resistor. The halogen gas quickly quenches the ionization and the GM tube returns to its high-resistance state, ready to detect more radioactivity.

Dead Time

For the short amount of the time the GM tube is detecting one particle, if another radioactive particle enters the tube it will not be detected. This is called dead time. The maximum dead time for the LND 712 GM tube used in the wand is 90 microseconds (or .00009 seconds). There is a mathematical formula for adjusting a Geiger counter readout to compensate for the GM tube's dead time. The adjustment is so small, however, that for practical applications it can be ignored.

Count Rate vs. Dose Rate

Each output pulse from the GM tube is a count. The counts per second give an approximation of the strength of the radiation field. Typically a GM tube is calibrated using either a cesium-137 or colbalt-60 radiation source. The chart is shown in figure 4 is a typical response curve for a generic GM tube. Each GM tube will have its own response curve to radiation. (For many of the GM tubes available on eBay, the response curve is not available.)



Measurement of Radiation

There are a few scales that one can use to measure radiation. Depending upon your application, one scale may serve you better than the others.

Radiation Measurements

Roentgen The measurement of energy produced by gamma or X-ray radiation in a cubic centimeter of air. It is abbreviated with the capital letter "R." One milliroentgen, abbreviated "mR" is one-thousandth of a roentgen. One microroentgen, abbreviated "uR" is one-millionth of a roentgen.

RAD Radiation Absorbed Dose is the original measuring unit for expressing the absorption of all types of ionizing radiation (alpha, beta, gamma, neutrons, etc.) into any medium. One rad is equivalent to the absorption of 100 ergs of energy per gram of absorbing tissue.

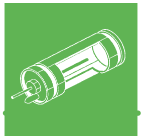
REM Roentgen Equivalent Man is a measurement that correlates the dose of any radiation to the biological effect of that radiation. Since not all radiation has the same biological effect, the dosage is multiplied by a "quality factor" (Q). For example, a person receiving a dosage of gamma radiation will suffer much less damage than a person receiving the same dosage from alpha particles, by a factor of three. So alpha particles will cause three times more damage than gamma rays. Therefore, alpha radiation has a quality factor of three. Following is the Q factor for a few radiation types:

Radiation	Quality Factor (Q)
Beta, Gamma and X-rays	1
Thermal Neutrons	3
Fast n, a, and protons	10
Heavy and recoil nuclei	20

The difference between the rad and rem is that the rad is a measurement of the radiation absorbed by the material or tissue. The rem is a measurement of the biological effect of that absorbed radiation. For general purposes, most physicists agree that the roentgen, rad, and rem may be considered equivalent. The curie is a unit of radioactivity. Its symbol (Ci) is defined by the amount radioactive decays per second. 1Ci = 3.7 x 10ˆ10 decays per second. When you purchase a radioactive isotope source, it will be rated in microcuries (uCi), or one millionth of a curie.

System International (SI) of Units

The System International of units for radiation measurements is now the official system of measurements. This system uses the "gray" (Gy) and "sivert" (Sv) for absorbed dose and equivalent dose respectively.



The conversion from one system to another is simple:

1 Sv = 100 rem	1 rem = .01 Sv
1 mSv = 100 mR (mrem)	1 mR = .01 mSv
1 Gy = 100 rad	1 rad = .01 Gy
1mGy = 100 mrad	1 mrad = .01 mGy

The SI derivative of the curie is the becquerel (Bq) **(pronounced: ‘be-kÐ-rel)**, which equals one decay per second.

How Much Radiation Is Safe?

In the United States the U.S. Nuclear Regulatory Commission (NRC) determines what radiation exposure level is considered safe. Occupational exposure for workers is limited to 5000 mrem per year. For the general population, the exposure is 500 mrem above background radiation in any one year. For long term, multi-year exposure, 100 mrem above background radiation is the limit set per year.

Let’s extrapolate the 100 mrem number to an hourly radiation exposure rate: 365 days/yr x 24 hr/day equals 8760 hours. Divide 100 mrem by 8760 hours, and it equals .0114 mrem/hr or 11.4/hr microrem. This is an extremely low radiation level. The background radiation in my lab hovers around 32 uR/hr. Am I in trouble? No. Typically background radiation in the United States averages 300 mrem/yr, or 34 microrem/hr. The NRC specification is for radiation above this 34 urem/hr background radiation.

Notice that my lab readings are in microrads (uR/hr) and the exposure limit is given in microrems (urem/hr). I do not know what type of radiation (a , b or y) the Geiger counter is reading in my lab at any particular instant, so I do not know the Q factor of the radiation and therefore can not calculate the mrem. For general purposes, I consider them the one and the same. The digital Geiger counters I use are calibrated using a Cs-137 radioactive source. Therefore, the highest accuracy in reading radiation levels will be from Cs-137 sources.

Common Radiation Exposure (General Population)

Background radiation consists of three sources; Cosmic radiation from the sun and stars. Terrestrial radiation from low levels of uranium, thorium, and their decay products in the soil, air and water. Internal radiation from radioactive potassium-40, carbon-14, lead-210, and other isotopes found inside our bodies.

Exposure	SourceDose (conventional)	Dose (SI)
Flight from LA to NY	1.5 mrem	.015 mSv
Dental X-ray	9 mrem	.09 mSv
Chest X-ray	10 mrem	0.1 mSv
Mammogram	70 mrem	0.7 mSv
Background Radiation	620 mrem/year	6.2 mSv/year

Testing for Radioactive Contamination

For this test to be as sensitive as possible it is recommended that the GM tube be sensitive to alpha, beta, and gamma radiation. Geiger counters can only test for gross radioactive contamination levels that will show up above background radiation levels. Low-level radioactive contamination may be effectively hidden within the natural “noise” of background radiation and not discernable using a Geiger counter. Therefore, for low-level radioactive contamination Geiger counters are not the proper test instruments. With this disclaimer in place, this is the procedure to test for radioactive contamination that presents an increase in the background radiation. First establish the background radiation level.

To establish background radioactivity level, record the pulses (counts) received per minute (CPM). The greater the number of minutes you count, the more accurate will be you background radiation reading. Average the CPM reading to determine an approximate background radiation level for your area. The highest and lowest CPM count will establish your minimum and maximum CPM. These numbers will establish a baseline so that you will be able to determine if the background radiation has changed, or to detect trace amounts of radioactive materials.

To run a test, position the probe (or Geiger counter) very close to the top surface of the material you are testing and run the counter, recording the CPM output. The longer you maintain the run obtaining the CPM data, the more accurate the results will be. Compare the radiation output of your sample to your established background radiation.