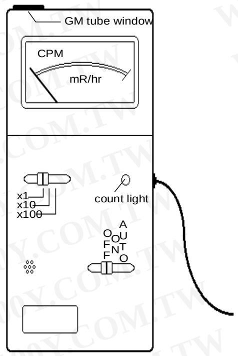
Radiation Monitor

(Order Code RM-BTD)

The Radiation Monitor is used to monitor alpha, beta, and gamma radiation. It can be used with a number of interfaces to measure the total number of counts per specified timing interval. Since it has its own analog display, it can also be used independent of interfaces in the field to measure radiation levels. The Radiation Monitor allows students to



- Detect the presence of a source of radiation.
- Monitor counts/interval (rate) as different thicknesses of a particular type of shielding are placed between the Geiger-Mueller tube of the Radiation Monitor and a beta or gamma source.
- Compare the effect of different types of materials to shield beta or gamma radiation.
- Set up a histogram with a very long run time to show students how initial “randomness” of data develops into a “bell-shaped” curve.
- Measure radiation of common radioactive materials, such as lantern mantels or old Fiestaware.
- Monitor variation in background radiation at different elevations.
- Monitor radioactivity in the environment over long periods of time.
- Monitor counts per interval (rate) from a beta or gamma radiation source as a function of the distance between the source and the Radiation Monitor.

This document describes the use of both the RM-BTD and RM-DG Radiation Monitors. Each of these Radiation Monitors includes a cable that allows the monitor to be connected to a data-collection interface.

The cable that accompanies the RM-BTD Radiation Monitor has a small 3.5 mm (micro-miniature) stereo jack on one end and a white rectangular British Telecom (BT) plug on the other end. This cable is used to directly connect the RM-BTD to the Vernier LabPro®, LabQuest® , or SensorDAQ® interfaces or to the Texas Instruments CBL 2™.

The cable that accompanies the RM-DG has a small 3.5 mm (micro-miniature) stereo jack on one end and a quarter-inch stereo plug on the other end. The RM-DG will plug directly into a ULI II.

Contact us if you want to use this radiation monitor with the original ULI.

NOTE: This product is to be used for educational purposes only. It is not appropriate for industrial, medical, research, or commercial applications.

Collecting Data with the Radiation Monitor

This sensor can be used with the following interfaces to collect data:

- Vernier LabQuest as a standalone device or with a computer
- Vernier LabPro with a computer, TI graphing calculator, or Palm® handheld
- Vernier SensorDAQ®
- CBL 2™

Here is the general procedure to follow when using the Radiation Monitor:

1. Connect the Radiation Monitor to the interface.
2. Start the data-collection software[1].
3. The software will identify the Radiation Monitor and load a default data-collection setup. You are now ready to collect data.

Specifications

Sensor: LND 712 halogen-quenched GM tube with a mica window, 1.5 to 2.0 mg/cm2 thick. Rated at 1000 counts per minute using a Cesium-137 laboratory standard.

Power: One 9-volt alkaline battery provides a battery life of 2000 hours at normal background radiation levels.

Accuracy: Noninstrumental aligned, approximately ±20% of full scale. Instrumental aligned, approximately ±10% of full scale.

Dimensions: 38 X 62 X 145 mm (1.5 X 2.8 X 5.7 in)

Weight: 245 g (8.8 oz) with battery installed

Energy Sensitivity:

Alpha: Down to 2.5 MeV; typical detection efficiency at 3.6 MeV is greater than 80%.

Beta: 50 KeV, typical 35% detection efficiency.

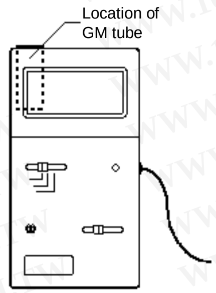
Gamma and X-rays: Down to 10 KeV typical through the end window, 40 KeV through the case.

Audio Output: Audible indication of each count available using the Audio switch position.

Temperature Range: 0 to 50°C

[1] If you are using Logger *Pro* 2 with either a ULI or SBI, the sensor will not auto-ID. Open an experiment file for the Low-g Accelerometer in the Probes & Sensors folder.

How the Radiation Monitor Works



The Radiation Monitor senses ionizing radiation by means of a Geiger-Mueller (GM) tube. The tube is fully enclosed inside the instrument. When ionizing radiation or a particle strikes the tube, it is sensed electronically and monitored by its own display, a computer, or by a flashing count light. When the switch is in the AUDIO position, the instrument will also beep with each ionizing event. It is calibrated for Cesium-137, but also serves as an excellent indicator of relative intensities for other sources of ionizing radiation. Gamma radiation is measured in milli-Roentgens per hour. Alpha and beta are measured in counts/minute (CPM). About 5 to 25 counts at random intervals (depending on location and altitude) can be expected every minute from naturally occurring background radiation.

The position of the GM tube is shown in Figure 2. The end of the tube has a thin mica window. This mica window is protected by the screen at the end of the sensor. It allows alpha particles to reach the GM tube and be detected. The mica window will also sense low energy beta particles and gamma radiation that cannot penetrate the plastic case or the side of the tube. Note: Some very low energy radiation cannot be detected through the mica window.

Further Tips for Monitoring Radiation

To measure gamma and X-rays, hold the back of the Radiation Monitor toward the source of radiation. Low-energy gamma radiation (10–40 KeV) cannot penetrate the side of the GM tube, but may be detected through the end window.

To detect alpha radiation, position the monitor so the suspected source of radiation is next to the GM window. Alpha radiation will not travel far through air, so put the source as close as possible (within 1/4 inch) to the screen without touching it. Even a humid day can limit the already short distance an alpha particle can travel.

To detect beta radiation, point the end window toward the source of radiation. Beta radiation has a longer range through air than alpha particles, but can usually be shielded (e.g., by a few millimeters of aluminum). High energy beta particles may be monitored through the back of the case.

To determine whether radiation is alpha, beta, or gamma, hold the back of the monitor toward the specimen. If there is an indication of radioactivity, it is most likely gamma or high energy beta. Place a piece of aluminum about 3mm (1/8") thick between the case and the specimen. If the indication stops, the radiation is most likely beta. (To some degree, most common radioactive isotopes emit both beta and gamma radiation.) If there is no indication through the back of the case, position the end window close to, but not touching, the specimen. If there is an indication, it is probably alpha or beta. If a sheet of paper is placed between the window, and the indication stops, the radiation is most likely alpha. (Note: In order to avoid particles falling into the instrument, do not hold the specimen directly above the end window.)

The Radiation Monitor does not detect neutron, microwave, radio frequency (RF), laser, infrared, or ultraviolet radiation. It is calibrated for Cesium-137, and is most accurate for it and other isotopes of similar energies. Some isotopes it will detect relatively well are cobalt-60, technicium-99m, phosphorus-32, and strontium-90.

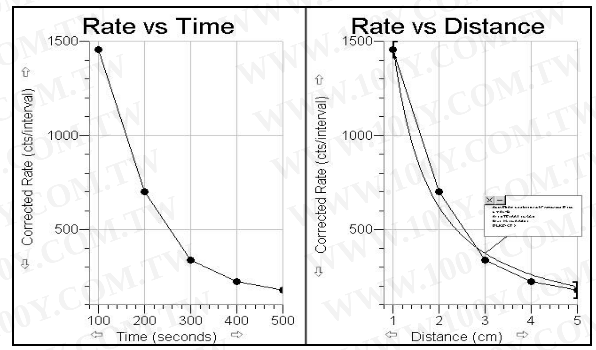
Some types of radiation are very difficult or impossible for this GM tube to detect. Beta emissions from tritium are too weak to detect using the Radiation Monitor. Americium-241, used in some smoke detectors, can overexcite the GM tube and give an indication of a higher level of radiation than is actually there.

Using the Radiation Monitor in Your Classes

Here are some examples of how the Radiation Monitor can be used in a science class.

Counts/Interval *vs.* Distance Studies

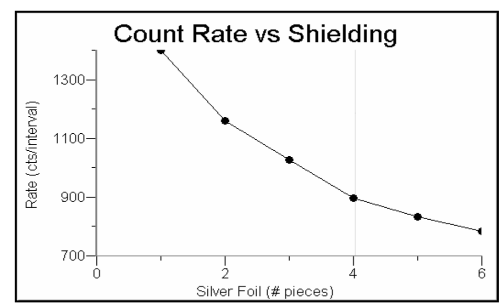
The data in the two graphs below were collected by monitoring gamma radiation at various distances from a Radiation Monitor. Data were collected with the run intervals set at 100 seconds. After each 100 second interval, the source was moved one centimeter further from the source. Since distance is proportional to time (300 seconds in the first graph corresponds to 3 cm in the second graph; 400 seconds to 4 cm, etc.), a new distance column was made using *time* divided by 100. The curved fit shown corresponds to distance raised to the –2 power (inverse squared).



Counts/interval vs. time and distance

Counts/Interval *vs.* Shielding Studies

The data shown here were collected by monitoring gamma radiation with an increasing number of pieces of silver foil placed between the source and a Radiation Monitor. Data was collected with the run interval set at 100 seconds. After each 100 second interval, another piece of silver foil was placed between the source and the Radiation Monitor. Since the number of pieces is proportional to time (300 seconds corresponds to 3 pieces of foil, 400 seconds to 4 pieces of foil, etc.), a new column, pieces of silver foil, was made using *time* divided by 100.



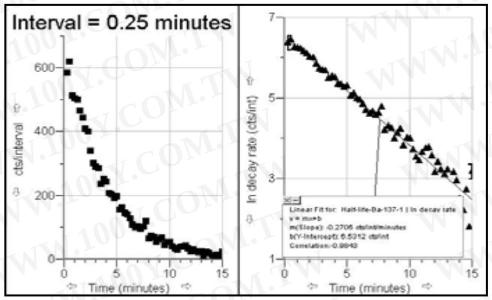
Counts/interval vs. thickness of filter

Half-life Determination (counts/interval *vs.* time)

Using a daughter isotope generator, it is possible to generate isotopes with a relatively short half-life. A solution that selectively dissolves a short half-life daughter isotope is passed through the generator. The linear plot of natural log of decay rate vs. time can be used to determine the half-life of the daughter isotope, using the formula

$$\ln 2 = k \cdot t_{1/2}$$

where k is the decay rate constant and $t_{1/2}$ is the half-life of the daughter isotope (in minutes).

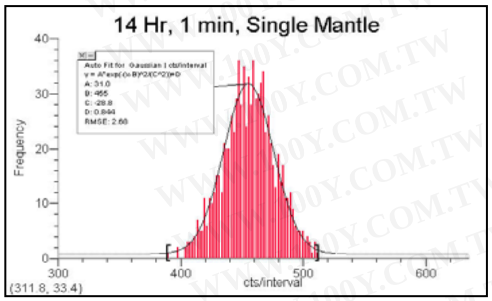


Half-life determination

In the plot of natural log of decay rate vs. time, the decay rate constant, k, is equal to $-m$. Using the slope value of m = –0.217 in the example here, the half-life was calculated to be 3.19 minutes.

Histogram Data Analysis

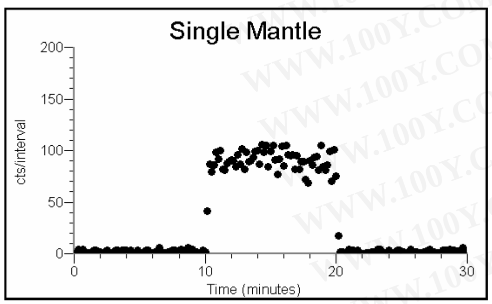
For an easy in-class experiment, set up a histogram with a very long run time and start data collection. Whenever the graph "overflows" the top of the graph, it will automatically be rescaled. This data collection shows students how initial "randomness" of data develops into a "bell-shaped" curve. A gamma radiation source was used.



A distribution graph

Lantern Mantels

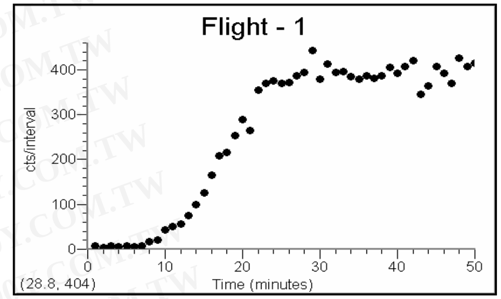
This graph shows a study of old and new Coleman mantle lanterns. These mantles formerly contained thorium and were often used for radiation demonstrations. In the early 1990s, Coleman changed the production methods and now the mantles are not radioactive.



New and old lantern mantles

Background Radiation

Here is an experiment performed in the days before airlines insisted that you turn off your personal computer before takeoff. It shows the counts/interval between takeoff and the time the plane reached its cruising altitude of 39,000 ft.



Radiation during an airline flight

Curricular Materials

Nuclear Radiation with Vernier by John Gastineau

This book has six experiments written for the Vernier Radiation Monitor and Student Radiation Monitor. Each of the six experiments has a computer version (for LabPro or ULI), a LabQuest version (for LabQuest), a calculator version (for LabPro or CBL 2), and Palm OS version (for LabPro). The Nuclear Radiation CD included with the book contains the word-processing files for all student experiments.

Radioactive Sources

If you don't have radiation sources, you may be able to obtain pre-1990 Coleman lantern mantles or other brands of lantern mantles (for a weak source of Thorium). You may also be able to find pottery, watches, clocks, or minerals that are moderately radioactive.

For something more active, order radioactive minerals from any of these scientific supply houses:

Flinn Scientific Inc.
phone (800) 452-1261
www.flinnsci.com

Spectrum Techniques
phone (423) 482-9937
www.spectrumtechniques.com

Canberra Industries
phone (203) 235-1347
www.canberra.com

RADIATION ALERT®

OPERATION MANUAL FOR THE MONITOR 4, MONITOR 4EC, MONITOR 5, AND MC1K

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.

TABLE OF CONTENTS

DESCRIPTION

The monitor senses ionizing radiation by means of a GM (Geiger Mueller) tube with a thin mica window. Note: There is no window on the MC1K. The tube is enclosed inside the instrument. When a ray or particle of ionizing radiation enters or passes through the tube, it is sensed electronically and displayed by a red count light. When the switch is in the AUDIO position, the instrument will also beep with each radiation event. About 5 to 25 counts at random intervals (depending on your location and altitude) can be expected every minute from naturally occurring background radiation.

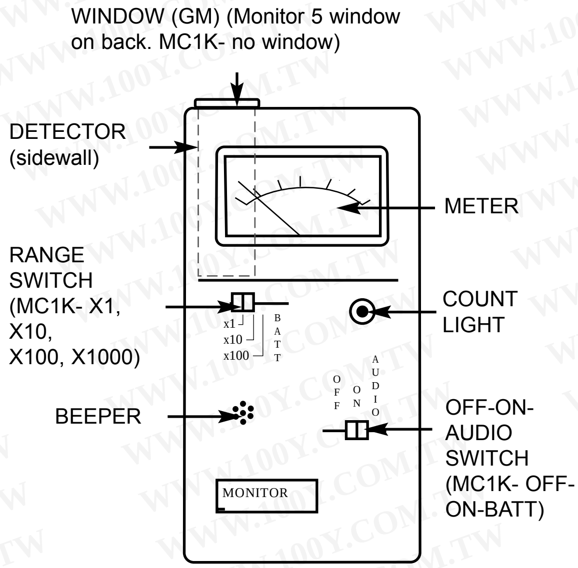


Illustration 1

OPERATION

1. Before turning on your instrument, install a 9 volt alkaline battery. If a battery is already installed, turn the instrument on and switch the range switch to the BATT position. Battery condition will be indicated on the meter.
2. Set the range switch in the X1 position. If the meter goes off scale, move the range switch to the next higher setting, X10, X100 or (X1000 MC1K only). **(Note: Refer to specifications for operating ranges.)**
3. For an audible signal, position the OFF/ON/AUDIO switch to the AUDIO position. **Note:** The flashes from the count light and the audible beeps are progressively shorter in X10, X100 or (X1000, MC1K only).

PRECAUTIONS

- Handle your instrument carefully as you would a camera.
- Avoid exposing the instrument to liquids, moisture, and corrosive gases; also avoid extreme temperatures or direct sunlight (i.e., car dashboards) for extended periods.
- Remove battery to prevent leakage if you do not plan to use the instrument for an indefinite period.
- The mica window of the GM tube can be easily damaged if struck directly. **DO NOT INSERT ANYTHING THROUGH THE SCREEN.**
- To avoid contamination, do not touch the instrument to the surface being tested.
- This instrument may be sensitive to and may not operate in radio frequency, microwave, electrostatic, and magnetic fields.
- Since the instrument has semiconductors in its circuitry, it is susceptible to EMP (electromagnetic pulse) and may be rendered inoperable by an atomic detonation. It has not been determined what distance from an atomic blast would be considered safe for semiconductor circuitry.

MAKING MEASUREMENTS

To determine whether the radiation detected is alpha, beta, or gamma hold the back of the instrument toward the source (see illustration 2 for location of Geiger tube).
Gamma; If there is an indication of radioactivity, it is most likely gamma or high energy beta. Low energy gamma and x-rays (10-40 keV) cannot penetrate the sidewall of the Geiger tube, but may be detected through the window. For the Monitor 5, hold the side of the instrument towards the source.
Beta; Place a piece of aluminum about 1/8" (3 mm) thick between the instrument and the source. If the indication stops, decreases, or changes, it is most likely beta radiation. Most common isotopes contain both beta and gamma.
Alpha; If there is no indication through the back of the case, position the window close to but not touching the source (see illustration 2). If there is an indication, it is alpha, beta, or low energy gamma. If a sheet of paper placed between

the window and the source stops the indication, it is most likely alpha. Do not hold the source above the window to avoid particles falling into the instrument.

SPECIFICATIONS

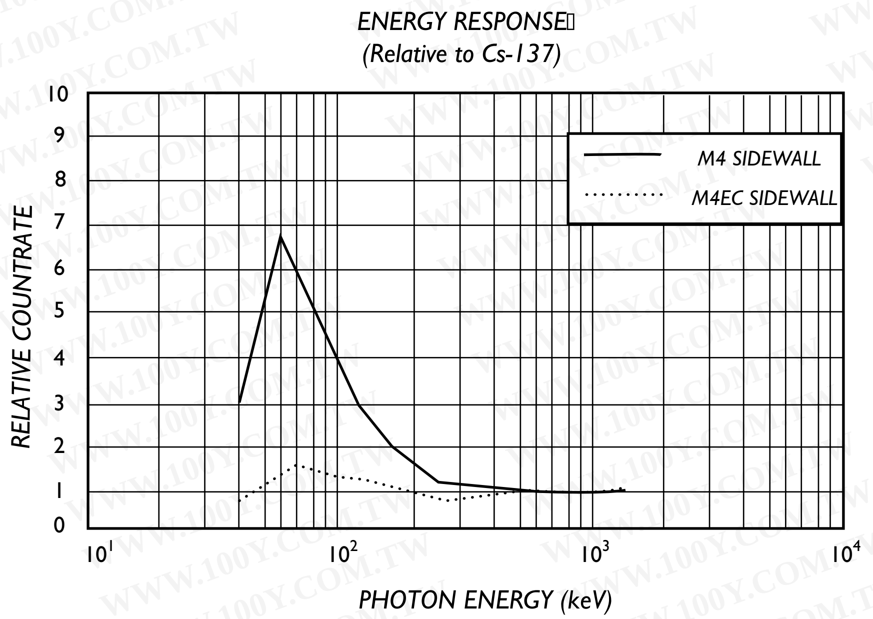
Detector for the MONITOR 4 and the MONITOR 4EC:
MONITOR 4- Halogen-quenched uncompensated GM tube Thin mica window is 1.5-2.0 mg/cm2 thick. Approx. 1,000 CPM/mR/hr for Cesium 137.
MONITOR 4EC- Halogen-quenched GM tube. Energy compensated sidewall with 2 mm tin filter. Thin mica window, 1.5-2.0 mg/cm2 thick. Approx. 1000 CPM/mR/hr for Cesium 137. Energy compensation is only effective through the sidewall of the GM (refer illustration 1).

MONITOR 4 Energy Sensitivity:

Detects alpha down to 2.5 MeV; typical detection efficiency at 3.6 MeV is greater than 80%.
Detects beta at 50 keV with typical 35% detection efficiency.
Detects beta at 150 keV with typica 75% detection efficiency.
Detects gamma and x-rays down to 10 keV typical through the window, 40 keV minimum through the case. (GRAPH 1).
Normal background is 5-20 CPM.

MONITOR 4EC Energy Sensitivity:

The energy response to gamma through the detector sidewall is flat to within +61% or -26% over the range of 40 keV to 100 keV, and within +35% or -17% over the range of 100 keV to - 1.3 MeV (referenced to Cs-137).
Detects alpha down to 2.5 MeV; typical detection efficiency at 3.6 MeV is greater than 80%.
Detects beta at 50 keV with typical 35% detection efficiency.
Detects beta at 150 keV with typical 75% detection efficiency.
Detects gamma and x-rays down to 10 keV typical through the window (non-compensated), 40 keV through the sidewall.
Normal background is approx. 5-20 CPM.



Graph 1

Operating Range- Monitor 4 and Monitor 4EC:

0-50 mR/hr and 0-50,000 CPM, or 0-500 mSv/hr and 0-50 mR/hr7/8" x 1 3/4" analog meter with dual scale.

Range Switch for the Monitor 4, Monitor 4EC:

X1, X10, X100, Battery Check. Refer to common specifications for more details

Detector for the MONITOR 5:

Halogen-quenched uncompensated GM tube with thin mica window, 1.5-2.0 mg/cm2 areal density. The effective diameter of the window is 1.13 in/28.58 mm.

MONITOR 5 Energy Sensitivity:

Referenced to Co-60, gamma sensitivity is 25 counts per second per 1 mR/hr. Recommended I-125 detection is for .5 mCi and up. Smallest detectable level of I-125 is approx. 0.02 mCi. Typical detection efficiencies compared to 2pi counter.

SOURCE	ENERGY	EFFICIENCY
Sr-90 (.035 mCi)	5.46 keV & 1.2 MeV b max	18%
Bi-210 (.0255 mCi)	1.16 MeV	20%
C-14 (.130 mCi)	156 keV b max	.07%

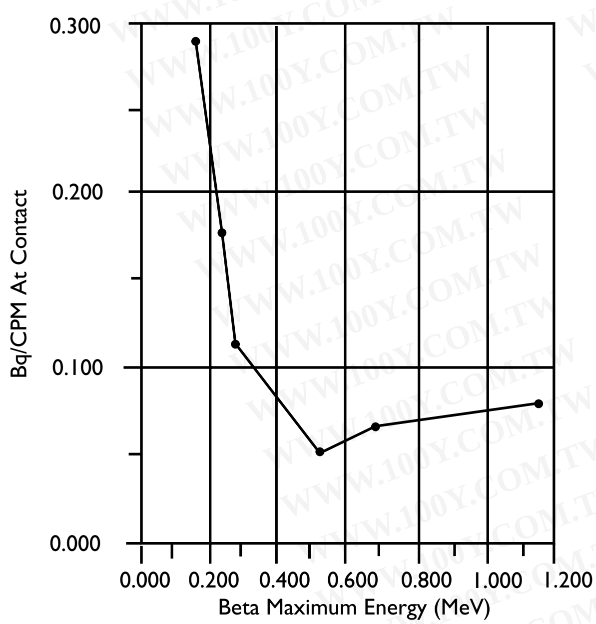
MONITOR 5

Beta Activity Determination

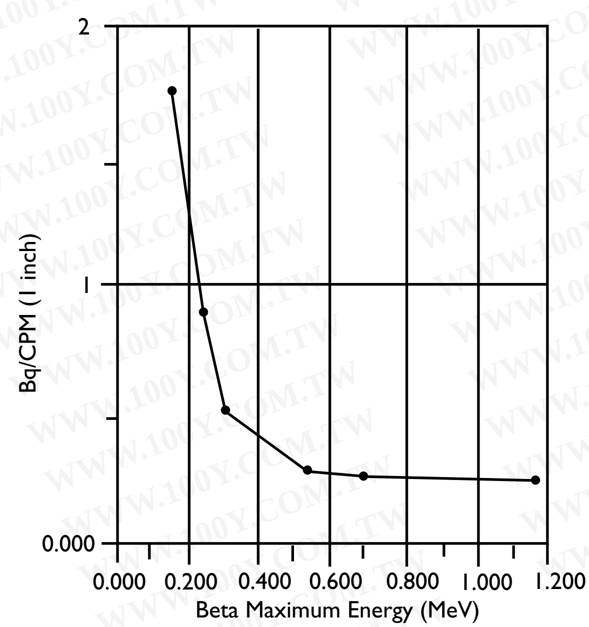
The following graphs enable the user to determine the activity of a known beta emitter from a measurement with the Monitor 5.

Radio Nuclide	Energy (MeV) Max.	Avg.	HALF LIFE	Bq/CPM Contact	1 inch
C-14	.156	.049	5730 y	.295	1.8
Pm-147	.225	.062	2.6234 y	.178	.89
Sr-90/Y-90	.546	.196	29.5 y	.054	.30
Cl-36	.710	.251	3.01x105 y	.066	.29
Bi-210	1.162	.389	22.3 y	.078	.28
Po-210	5.305		138.376 d	.129	11.0

To determine the activity of a known beta emitter, make a measurement with the Monitor 5 at a distance of one inch from the source or just above contact with the source. Look up the maximum energy level of the source on the appropriate graph to determine the Bq/CPM number for that source. Multiply the Monitor 5 reading times the Bq/CPM. The result will be the activity of the source in Becquerels. Note: The diameter of the test source should be equal to or smaller than the detector diameter.



Graph 2



Graph 3

Operating Range-MONITOR 5:

0-500, 0-5000, 0-50,000 CPM. Each range is independently calibrated.

Optional tri-scale:

0-12.5, 0-125, 0-1,250 CPS
0-.5, 0-5, 0-50 mR/hr
0-5, 0-50, 0-500 mSv/hr. 7/8” x 1 3/4” analog meter.

Range Switch for the Monitor 5

X1, X10, X100, Battery Check. **Refer to common specifications for more details**

Detector for the MC1K:

Energy compensated halogen-quenched GM tube no window.

MC1K Energy Sensitivity:

Detects gamma and x-rays down to 40 keV. Response is flat from 40 keV up. Normal background, avg. 4 CPM (counts per minute)

Range Switch for the MC1K:

X1, X10, X100, X1000

Operating Range- MC1K:

X1 position (in .05 increments) 0 to 1 mR/hr or 0 to .01 mSv/hr (milli-Sievert per hour)
X10 position (in .5 increments) 0 to 10 mR/hr or 0 to .1 mSv/hr
X100 position (5) 0 to 100 mR/hr or 0 to 1 mSv/hr
X1000 position (50) 0 to 1000 mR/hr (1R) or 0 to 10 mSv/hr
7/8” x 1 3/4” analog meter.

COMMON SPECIFICATIONS FOR THE MONITOR 4, MONITOR 4EC, MONITOR 5, AND MC1K

Accuracy:

± 15% of full scale (referenced to Cs-137)

Audio:

Built-in piezoelectric transducer gives audible beep when switch is in the AUDIO position. Can be switched off for silent operation. Note: The MC1K audio cannot be switched off.

Anti-Saturation:

Meter will hold at full scale in fields as high as 100 times the maximum reading

Operating Voltage :

7-11 Volts DC. High and low voltage is fully regulated

Power Requirements:

One 9 Volt alkaline battery. Battery life is up to 2,000 hours at normal background radiation levels.

Temperature Range:

-20°C to 55°C (-4° F to 131° F)

Weight:

Monitor 4: 178 grams (6.3 oz.) without battery
Monitor 4EC: 198 grams (7 oz.) without battery
Monitor 5: 240.5 grams (8.5 oz.) without battery
MC1K: 188 grams (6.4 oz.) without battery

Size:

145 x 72 x 38 mm (5.7 x 2.8 x 1.5 in.)

Includes:

1 year limited warranty, carrying case, and CE mark.

Options for the Monitor 4, Monitor 4EC, and MC1K:

Stainless steel belt clip (attached to instrument)

CALIBRATION

Factory calibration is by pulse generator and is typically ±15% of full scale relative to Cesium 137. For calibration to N.I.S.T. standards, contact the manufacturer, distributor, or a certified lab.

Calibration Procedure for the Monitor 4, Monitor 4EC, and MC1K: Position the instrument upright with the back of the instrument facing the source. (refer to Illustration 2 and 3) Adjust the height of the instrument so the center of the tube (lengthwise) will be centered with the beam. Measure the appropriate distance from the source to the center of the tube’s diameter and length.

To adjust the calibration, simply remove the two switch knobs on the front of the case. On the back of the case, remove the two top screws and the two screws from inside the battery compartment. Ease off the front of the case and adjust the trimpot located above the OFF/ON/AUDIO switch.

The position of the GM tube detector is shown in illustrations 3 and 4. The window of the tube is very thin mica. This mica window is protected by a screen (the MC1K does not have a window). Some levels of alpha, low energy beta, gamma, and x-rays that cannot penetrate the plastic case or the side of the tube can be sensed through the window. See Specifications for the GM tube sensitivities.

Try not to touch the instrument to any suspected radioactive substance. Although some beta and most gamma radiation can go through protective gear, try to avoid skin contamination and ingestion. When you leave a radioactive area, remove any protective outerwear and dispose of properly. If you think you have been contaminated, as an additional precaution, shower and consult a physician.

BRIEF OVERVIEW OF RADIATION DETECTION

None of the instruments listed in this manual detect neutron, microwave, RF (radio frequency), laser, infra-red, or ultra-violet radiation.

All of the instruments are most accurate for Cesium 137 and isotopes of similar energies. Some isotopes detected relatively well are Cobalt 60, Technicium 99M, Phosphorous 32, Strontium 90, and many forms of Radium, Plutonium, Uranium, and Thorium.

Some forms of radiation are very difficult or impossible for a Geiger tube to detect. Tritium is a by-product of a nuclear reactor and is used in research. The beta emissions from Tritium are so weak that there is very little instrumentation that is capable of detecting it. Other examples of when more sophisticated equipment is needed are for the measurement of contamination in environmental samples, such as radioactivity in milk, produce, soil, etc..

The radiation from some isotopes can cause a Geiger tube to overexcite and cause an indication of a higher level of radiation than is actually there. Americium 241 is an example of this phenomenon. Americium 241 is used in some smoke detectors and many different types of industrial density and flow meters.

Unless you know exactly what you are measuring and understand the limitations of detection instruments, it is possible to draw misleading conclusions from your readings. We designed our instruments to be able to detect the broadest range of ionizing radiation possible and remain in the price range of the average person. The full spectrum of ionizing radiation cannot be measured by one single instrument.

Everyone agrees that radioactive materials can be dangerous. We encourage you to seek out other sources of information.

POSSIBLE HOUSEHOLD SOURCES OF RADIATION

SMOKE DETECTORS: Some smoke detectors contain a sealed radioactive isotope as part of the smoke sensing mechanism.

CAMPING LANTERN MANTLES: In recent years this has changed but, some lantern mantles are made with radioactive Thorium. Be especially careful not to inhale or ingest the fine ash that is left when they are burned out.

CLOCKS, WATCHES, AND TIMERS: Many old timepieces have dials painted with radium to make them glow in the dark. Tritium is now commonly used to obtain the same effect. Tritium is also radioactive but emits low energy radiation which cannot penetrate the lens of the timepiece.

JEWELRY: Some gold used to encapsulate radium and radon for medical purposes was improperly reprocessed and entered the market as radioactive rings and other types of gold jewelry. Some imported cloisonne being glazed with uranium oxide exceeds U.S. limits.

Some gems are irradiated by an electron beam or in an accelerator to enhance their color. Irradiated gems typically are held until there is no residual activity remaining.

ROCK COLLECTIONS: Many natural formations contain radioactive materials. Hobbyists who collect such things should vent the rooms in which these items are stored and be careful to avoid inhaling the fine dust particles from these samples.

POTTERY: Some types of pottery is glazed with uranium oxide. To the best of our knowledge, this process has been discontinued, although some of these pieces are still in circulation.

GLOSSARY

ALPHA: Positively charged particles emitted from the nucleus of an atom. Alpha particles are relatively large, and very heavy. Due to this strong (+) charge and large mass, an alpha particle cannot penetrate far into any material. A sheet of paper or an inch of air can usually stop most alpha particles.

BACKGROUND RADIATION: Naturally occurring radiation is always present, it includes high energy gamma rays from the sun and outer space and alpha, beta, and gamma radiation emitted from elements in the earth.

BETA PARTICLES: Negatively charged particles emitted from an atom. Beta particles have a mass and charge equal to that of an electron. They are very light particles (about 2,000 times less mass than a proton) and have a charge of -1. Because of their light mass and single charge, beta particles can penetrate more deeply than alpha particles. A few millimeters of aluminum will stop most beta particles.

Bq (Becquerels): A quantity of radioactivity in which one atom is transformed per second. 1 dps (one disintegration per second).

CPM (counts per minute): The unit of measurement usually used to measure alpha and beta radiation.

The position of the GM tube detector is shown in illustrations 3 and 4. The window of the tube is very thin mica. This mica window is protected by a screen (the MC1K does not have a window). Some levels of alpha, low energy beta, gamma, and x-rays that cannot penetrate the plastic case or the side of the tube can be sensed through the window. See Specifications for the GM tube sensitivities.

Try not to touch the instrument to any suspected radioactive substance. Although some beta and most gamma radiation can go through protective gear, try to avoid skin contamination and ingestion. When you leave a radioactive area, remove any protective outerwear and dispose of properly. If you think you have been contaminated, as an additional precaution, shower and consult a physician.

BRIEF OVERVIEW OF RADIATION DETECTION

None of the instruments listed in this manual detect neutron, microwave, RF (radio frequency), laser, infra-red, or ultra-violet radiation.

All of the instruments are most accurate for Cesium 137 and isotopes of similar energies. Some isotopes detected relatively well are Cobalt 60, Technicium 99M, Phosphorous 32, Strontium 90, and many forms of Radium, Plutonium, Uranium, and Thorium.

Some forms of radiation are very difficult or impossible for a Geiger tube to detect. Tritium is a by-product of a nuclear reactor and is used in research. The beta emissions from Tritium are so weak that there is very little instrumentation that is capable of detecting it. Other examples of when more sophisticated equipment is needed are for the measurement of contamination in environmental samples, such as radioactivity in milk, produce, soil, etc..

The radiation from some isotopes can cause a Geiger tube to overexcite and cause an indication of a higher level of radiation than is actually there. Americium 241 is an example of this phenomenon. Americium 241 is used in some smoke detectors and many different types of industrial density and flow meters.

Unless you know exactly what you are measuring and understand the limitations of detection instruments, it is possible to draw misleading conclusions from your readings. We designed our instruments to be able to detect the broadest range of ionizing radiation possible and remain in the price range of the average person. The full spectrum of ionizing radiation cannot be measured by one single instrument.

Everyone agrees that radioactive materials can be dangerous. We encourage you to seek out other sources of information.

POSSIBLE HOUSEHOLD SOURCES OF RADIATION

SMOKE DETECTORS: Some smoke detectors contain a sealed radioactive isotope as part of the smoke sensing mechanism.

CAMPING LANTERN MANTLES: In recent years this has changed but, some lantern mantles are made with radioactive Thorium. Be especially careful not to inhale or ingest the fine ash that is left when they are burned out.

CLOCKS, WATCHES, AND TIMERS: Many old timepieces have dials painted with radium to make them glow in the dark. Tritium is now commonly used to obtain the same effect. Tritium is also radioactive but emits low energy radiation which cannot penetrate the lens of the timepiece.

JEWELRY: Some gold used to encapsulate radium and radon for medical purposes was improperly reprocessed and entered the market as radioactive rings and other types of gold jewelry. Some imported cloisonne being glazed with uranium oxide exceeds U.S. limits.

Some gems are irradiated by an electron beam or in an accelerator to enhance their color. Irradiated gems typically are held until there is no residual activity remaining.

ROCK COLLECTIONS: Many natural formations contain radioactive materials. Hobbyists who collect such things should vent the rooms in which these items are stored and be careful to avoid inhaling the fine dust particles from these samples.

POTTERY: Some types of pottery is glazed with uranium oxide. To the best of our knowledge, this process has been discontinued, although some of these pieces are still in circulation.

GLOSSARY

ALPHA: Positively charged particles emitted from the nucleus of an atom. Alpha particles are relatively large, and very heavy. Due to this strong (+) charge and large mass, an alpha particle cannot penetrate far into any material. A sheet of paper or an inch of air can usually stop most alpha particles.

BACKGROUND RADIATION: Naturally occurring radiation is always present, it includes high energy gamma rays from the sun and outer space and alpha, beta, and gamma radiation emitted from elements in the earth.

BETA PARTICLES: Negatively charged particles emitted from an atom. Beta particles have a mass and charge equal to that of an electron. They are very light particles (about 2,000 times less mass than a proton) and have a charge of -1. Because of their light mass and single charge, beta particles can penetrate more deeply than alpha particles. A few millimeters of aluminum will stop most beta particles.

Bq (Becquerels): A quantity of radioactivity in which one atom is transformed per second. 1 dps (one disintegration per second).

CPM (counts per minute): The unit of measurement usually used to measure alpha and beta radiation.

GAMMA RAYS: Short wavelength electromagnetic radiation higher in frequency and energy than visible and ultraviolet light. Gamma rays are emitted from the nucleus of an atom. These high energy photons are much more penetrating than alpha and beta particles.
ION: An atomic particle, atom, or molecule that has acquired an electrical charge, either positive or negative, by gaining or losing electrons.
IONIZATION: The process by which neutral atoms of molecules are divided into pairs of oppositely charged particles known as ions.
IONIZING RADIATION: Radiation capable of producing ionization by breaking up atoms or molecules into charged particles called ions.
RADIATION: The emission and propagation of energy through space or through matter in the form of particles or waves.
ROENTGEN (rent-gen): A basic unit of measurement of the ionization produced in air by gamma or x-rays. One Roentgen (R) is exposure to gamma or x-rays that will produce one electrostatic unit of charge in one cubic centimeter of dry air. One thousand milliroentgen (1,000 mR)= 1R.
RADIOISOTOPE: A natural occurring or artificially produced radioactive form of an element.
SIEVERT: A unit of dose equivalent. 1 Sv= 100 roentgens, 10 mSv/hr = 1 milliroentgen/hr. (mSv micro-Sievert, micro is one millionth, milli is one thousandth.)
X-RAYS: Electromagnetic radiation (photons) of higher frequency and energy than visible and ultraviolet light, usually produced by bombarding a metallic target with high speed electrons in a vacuum. X-rays are photons emitted by interactions involving orbital electrons rather than atomic nuclei. X-rays and gamma rays have the same basic characteristics. The only difference between them is their source of origin.

LIMITED WARRANTY

ELEMENTS OF WARRANTY: This warranty covers all materials and craftsmanship in this product to be free from defect for a period of one year with only the limitations or exclusion set out below.
WARRANTY DURATION: This 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 the defect or malfunction covered by this Warranty, d) used in a manner or purpose for which the instrument was not intended or contrary to the written instructions or e) is contaminated with radioactive material. This warranty does not apply to any product subject to corrosive elements, misuse, abuse, or neglect.
STATEMENT OF REMEDY: In the event the product does not conform to this warranty at any time while this warranty is effective, the Warrantor will repair the defected and return 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 reimbursement or payment of incidental or consequential damages arising from the use of 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 period, all such liability shall terminate. Any implied warranty is limited to the duration of this written warranty.
PROCEDURE FOR OBTAINING PERFORMANCE OF WARRANTY: In the event that the product does not conform to this warranty, please contact your local distributor.
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 connected with such use.