Victoreen® 90-12

Energy Compensated GM Probe

Users Manual

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Section 1
Introduction

1.1 Product Description

The 90-12 is a rugged, lightweight, energy compensated, general purpose Geiger Mueller (GM) tube based hand held probe, with beta shields. These probes are designed to fulfill a variety of radiation measurement needs. The adjustable beta shield is a 360-degree shield with a linear movement to permit discrimination between penetrating and non-penetrating radiation. The two windows expose an angle of 180 degrees total in the most sensitive area of the GM tube. With the shield open the probes measure beta, x-rays, and gamma rays. With the beta shield closed the probes measure penetrating x-rays and gamma rays. The GM probes are available with MHV or BNC connectors. A coiled coaxial cable style is available to connect these probes to a wide variety of Victoreen survey meters. Refer to Figure 1-1 for a general view.

The energy compensation feature permits accurate exposure rate measurements from background to the maximum range.

1.2 Specifications

Operating Voltage	900 V
Plateau length	100 V (min)
Plateau Slope	0.1 %/V (max)
Temperature Range	-40°F to +167°F (-40°C to +75°C)
Relative Humidity	0-95% non-condensing
Wall Thickness	30 mg/cm^2 (tube)
Wall Material	Stainless Steel
Maximum Background	15 CPM
Gamma Sensitivity **** Calibrated to ^{137}Cs***	700 CPM/mR/hr*
Energy Response	See curve
Housing	ABS plastic
Beta Shield Density	1890 mg/cm^2
Connector	MHV
Size	1.38 in ∅ x 6.7 in (l) (3.5 x 17 cm)
Weight	0.58 lb (0.26 kg)

1.3 Connecting Cables

The following cables are available to connect the survey instruments and probes. Make sure that you have chosen cables with compatible connectors since both instruments and probes come with MHV connectors.

Coil Cable with MHV connectors: P/N 489-99

1.4 Survey Meter Compatibility and Range Guide

Table 1-1 shows the compatibility of the 90-12 probe with Victoreen survey meters. Because the characteristics of survey meters differ, the table also shows the radiation rate range of the probe with each survey meter. Table 1-1 shows the maximum possible ranges. Other scales are possible on the compatible survey meters and recommended for different applications.

Table 1-1. Probe Compatibility

Survey Meters	**90-12 Probe**
Model 90	0-1 R/hr
Model 190	0-1 R/hr
Model 290	0-1 R/hr

1.5 Photon Energy Response

Figure 1-1 shows the photon energy response of the 90-12 probe with the slide open and closed.

The energy compensator permits reliable exposure rate measurements from background to 200 mR/h.

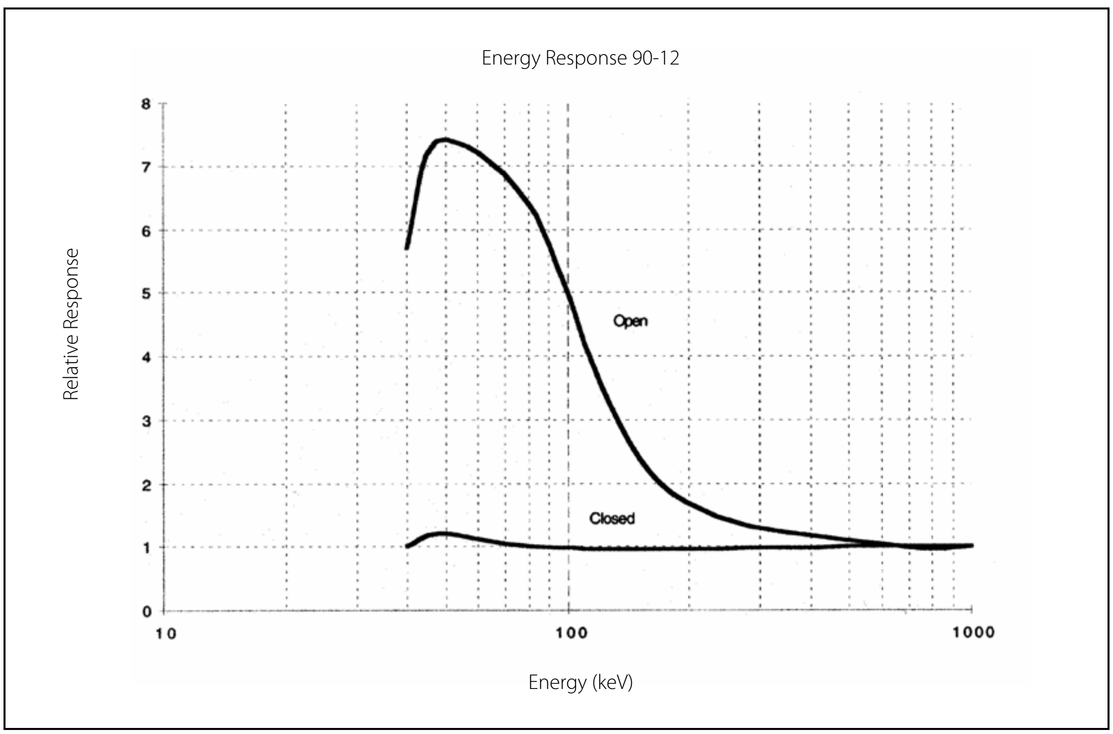

Figure 1-1. Photon Energy Response

The energy response curve represents data taken below a rate of 200 mR/hr. Changes in the actual curve could occur at rates over 200 mR/hr.

1.6 Beta Sensitivity, Slide Open

Table 1-2 shows the beta sensitivity of the 90-12 probe to a variety of sources.

Table 1-2. Beta Sensitivity

Nuclide	Particle	Energy Max (MeV)	90-12 Sensitivity CPM/Ci
^{90}Sr	Beta	2.245/.544	362,000
^{137}Cs	Beta/Gamma	1.176/0.662	45,662
^{36}Cl	Beta	0.714	92,827
^{99}Tc	Beta	0.295	560
^{14}C	Beta	0.158	0

These data were taken with the beta shield moved to expose the open window. For these measurements, one of the two windows was pointed directly at the source.

1.7 Beta Shield Response

The beta shield has a total average attenuation of 1890 mg/cm^2. This rejects all alpha particles, beta rays with an energy of 2.5 MeV or less, and non-penetrating x-rays when the slide covers the GM tube. See the energy response curves for open and closed slide positions.

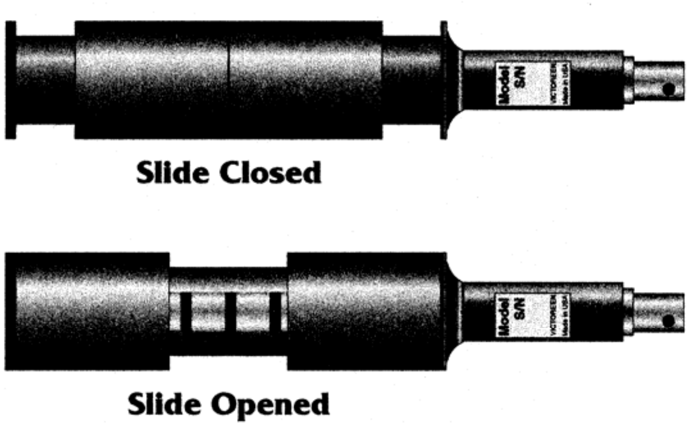

Figure 1-2. General View

CAUTION

To avoid getting pinched when opening the BETA shield, twist sleeves and gently slide BETA shield apart.

1.8 Receiving Inspection

Upon receipt of the package:

1. Inspect the cartons (s) and contents for damage. If damage is evident, file a claim with the carrier and notify Fluke Biomedical, Radiation Management Services at 440.248.9300.
2. Remove the contents from the packing material.
3. Verify that all items listed on the packing list have been received and are in good order.

1.9 Storage

If the unit is to be stored prior to use, pack it in the original container if possible, and store in an environment free of corrosive materials, fluctuations in temperature, and humidity, and vibration and shock.

Prior to use, check the condition and functionality of the probe. Also check that the calibration is still valid. Routine recalibrations are usually required by individual radiation safety programs. Please consult your local radiation safety office if you have any questions.

1.10 Procedures, Warnings, and Cautions

The equipment described in this manual is intended to be used for the detection and measurement of ionizing radiation. It should be used only by persons who have been trained in the proper interpretation of its readings and the appropriate safety procedures to be followed in the presence of radiation.

Although the equipment described in this manual is designed and manufactured in compliance with all applicable safety standards, certain hazards are inherent in the use of electronic and radiometric equipment.

WARNINGS and **CAUTIONS** are presented throughout this document to alert the user to potentially hazardous situations. A **WARNING** is a precautionary message preceding an operation that has the potential to cause personal injury or death. A **CAUTION** is a precautionary message preceding an operation that has the potential to cause permanent damage to the equipment and/or loss of data. Failure to comply with **WARNINGS** and **CAUTIONS** is at the user's own risk and is sufficient cause to terminate the warranty agreement between Fluke Biomedical and the customer.

Adequate warnings are included in this manual and on the product itself to cover hazards that may be encountered in normal use and servicing of this equipment. No other procedures are warranted by Fluke Biomedical. It shall be the owner's or user's responsibility to see to it that the procedures described here are meticulously followed, and especially that WARNINGS and CAUTIONS are heeded. Failure on the part of the owner or user in any way to follow the prescribed procedures shall absolve Fluke Biomedical and its agents from any resulting liability.

Section 2
Operation

2.1 General

The 90-12 is a hand held probe, sensitive to most types of radiation and designed for general survey use in concert with Victoreen analog and digital survey meters. The feature of an adjustable beta shield permits discrimination between penetrating and not penetrating radiation.

2.2 Compatibility

The 90-12 probe is designed to be compatible with the following Victoreen general-purpose survey instruments:

- 90 Analog Survey Meter
- 190 Digital Survey Meter
- 290 Analog Survey Meter

Before connecting or disconnecting the probe or the cable to the survey meter, make sure that the power to the instrument is turned OFF.

CAUTION

Connecting or disconnecting the probe or the cable to the instrument with the instrument power turned ON may cause damage to the instrument.

There is a potential for shock hazard when the probe or cable is connected or disconnected from the instrument when the instrument power is turned ON. Be careful not to touch high voltage at any time.

If readings from a probe and survey meter indicates that the radiation rate is relatively high, CAUTION should be observed when surveying. High rates can quickly cause the operator's cumulative exposure to increase with the potential for injury.

2.3 Initial Connection

Connect the probe to the survey instrument. Turn on the survey instrument. Note background readings. Use the check source on the side of the instrument or any check source available to verify proper operation. Check to make sure that the probe and/or instrument calibration has not expired prior to use.

2.4 Use in Adverse Conditions

Because of its ruggedness, wide temperature range, and the fact that it is moisture resistant, the probe may be used in a variety of adverse conditions. For example, the probe may be used out of doors at any time of the year and even in the rain and fog. It is NOT recommended, however, that the probe be submerged.

2.5 The Beta Shield

With the beta shield in the closed position, that is covering the open window, the probe measures only penetrating radiation such as x-rays and gamma rays. In this configuration the probe will not respond to beta rays or alpha particles.

The probe's windows may be opened by gently twisting and pulling both shield halves apart. When each half has reached its limit of travel the windows are maximally exposed. In this mode the probe will respond to beta rays, x-rays and gamma rays.

Measuring a particular location with and without the shield in place can provide information about the nature and type of radiation present. If beta rays or very low energy x-rays are present then the readings with the beta shield open will yield higher readings than the readings with the shields closed.

2.6 The Open Windows

There are two windows opposite each other on the barrel of the probe. This area is the central and most sensitive part of the GM tube. Each window subtends 90 degrees of arc. Together they subtend 180 degrees or 2 radians. This permits maximum independence of directionality. For best results, when surveying for beta rays on surfaces, the operator should orient the probe so that one of the open windows points directly at the surface.

2.7 Error Analysis

From the sensitivity of the probes and the Gaussian distribution statistical model for radioactive decay measurements, the measurement error can be calculated directly as a function of exposure rate and the counting time for each probe. For this distribution the standard deviation is the square root of the number of counts ($\sigma=\sqrt{\text{Total Counts}}$). The total number of counts is equal to the exposure rate times the tube characteristic times the total counting time (Total Counts = Exposure Rate x Tube Characteristic x Time). The total counts is the mean or expected measurement.

It is also given for gaussian distributions that 99.73% of the actual measurements will fall within the mean plus or minus three standard deviations ($\mu \pm 3\sigma$). This is then chosen as the error range.

From the above discussion the accuracy of any probe can be computed.

2.8 Minimum Detectability

Minimum detectability depends on local background levels and, in the presence of a radiation background, is usually calculated at the 50% and 95% confidence level. A good first approximation to each is as follows: First, determine the mean and standard deviation of the background. Look up the sensitivity of the probe to the nuclide. Factor in any geometry efficiency. The 50% confidence level is the activity level, accounting for geometry and sensitivity, of the nuclide at the mean plus 3.0 standard devia

tions of the background. For the 95% confidence level use the mean plus 4.645 standard deviations of the background.

Section 3
Theory of Operation

3.1 General

X-rays, gamma rays, beta rays and alpha particles produce charged particles in a gas. These charged particles are negatively charged electrons and positively charged ions. An electron and a positively charged ion are called an ion pair. Collecting these ion pairs formed in a gas filled chamber permits quantification of the incident radiation.

Charged particles, such as alphas and betas, produce ion pairs through direct action, either by colliding with electrons in matter or the interaction of electrical fields. This process is called ionization.

Uncharged particles, such as photons, produce ion pairs through indirect action. They interact with matter to form charged particles, which then produce ion pairs as described above.

The number of ion pairs formed in a gas depends upon the type and energy of the incident radiation and the nature of the gas. Each different gas has its own ionization potential, that is, the amount of energy necessary to cause one ion pair to form.

If left to themselves, negative electrons and positive ions will recombine to form neutral atoms again. However, if an electric field is applied, via the application of a high voltage to the gas, then the negative electrons will move toward the positive electrode and the positive ions will move toward the negative electrode. This causes a current to flow.

This current is usually very small, usually too small to measure under ordinary conditions, therefore, some method for amplifying the current is needed. It is desirable to operate the detector in such a way that each individual interaction process gives rise to a detectable pulse. This is accomplished via the external circuit design and through gas multiplication.

A few free electrons, under the influence a strong enough electric field, may have enough kinetic energy that when they collide with neutral atoms they also ionize these atoms. If this process begins and repeats itself many times it produces a cascade of electrons. This cascade works like an avalanche and produces a pulse of many charged electrons. This is called gas multiplication.

In a Geiger Mueller tube the formation of only one free electron in the gas volume is usually enough to initiate an avalanche.

The Geiger Mueller pulse or avalanche ends when a high enough positive ion concentration is formed in the gas to reduce the intensity of the electric field. Any ionization event that occurs during this time will not produce an avalanche or pulse. During this time the tube is said to be "dead." After a short time period these ions dissipate enabling the tube to respond normally once more.

Geiger Mueller tubes are filled with some small amount of "quench" gas to help end the pulse period by absorbing some of the free energy in the system.

If the voltage on the Geiger Mueller tube is too high, or the radiation rate is too high, the Geiger Mueller tube will continuously discharge because a continuous arc of current will have been formed.

3.2 Circuit Description

A simplified equivalent circuit is shown in Figure 3-1.

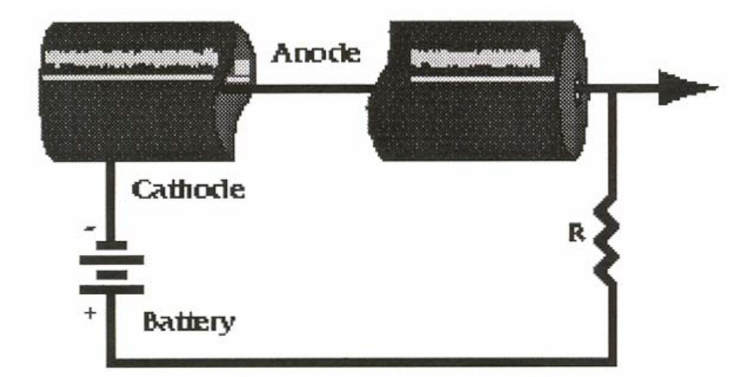

Figure 3-1. Circuit Diagram

High voltage is applied to the anode and the cathode is at electrical ground. If the gas volume detects a free electron from an ionization event, and a current pulse occurs, this will appear as a momentary decreased voltage across the resistor.

Section 4
Calibration, Maintenance, and Troubleshooting

4.1 Calibration

4.1.1Precautions

Only trained and qualified personnel operating within the protocols of an approved radiation protection program should be permitted to calibrate any radiation device.

4.1.2Standards

The 90-12 probe is calibrated at the factory against NIST traceable standards. The standard factory calibration is to ^{137}Cs gamma rays. Calibrations other than to standard nuclides are available upon request. The sensitivity of the probe is provided on the calibration documentation.

4.1.3Factory Calibration Points

The probe is calibrated in conjunction with a survey instrument, and generally at 1/3 & 2/3 of full scale on all survey meter ranges.

4.2 Preventive Maintenance

The probe should be kept clean and free from dirt and contamination. There is no other preventative maintenance required. Remember to periodically have the probe recalibrated per the requirements of the local radiation safety program.

The probe may be cleaned using any commercially available cleaning or decontaminating agent. While the GM probe is sealed against moisture, care should be taken NOT to submerge the probe in water or any cleaning agent.

CAUTION

Any attached survey instrument should be turned off or the probe disconnected from the survey instrument prior to any probe cleaning procedure.

4.3 Corrective Maintenance/Troubleshooting

Should the cable between the probe and the survey instrument be found to be frayed, immediately repair or replace the cable.

If a probe stops counting, several possible failure modes are a loose connection or a broken GM tube.

4.3.1 Precautions

Before connecting or disconnecting the probe or the cable to the survey meter, make sure that the power to the instrument is turned OFF.

CAUTION

Connecting or disconnecting the probe or the cable to the instrument with the instrument power turned ON may cause damage to the instrument.

There is a potential for shock hazard when the probe or cable is connected or disconnected from the instrument when the instrument power is turned ON. Be careful not to touch high voltage at any time.

Disconnect the probe from the cable and/or survey instrument prior to any disassembly or reassembly.

4.3.2 Disassembly

The end cap is held onto the main body via an interference fit. Refer to the drawing. The cap may be forced off by applying a uniform pressure around the edge of the cap in an axially outward direction. Removing the end cap exposes all of the inner parts. Do not lose any small pieces. The electrical connector may be removed by unscrewing it from the main body in a counterclockwise direction. This does not permit access, however, to all of the inner parts.

4.3.3 Reassembly

The probe may be reassembled by aligning and inserting parts according to their location indicated on the drawing. The cap may be reattached by applying a compressive force onto the cap in an inward axial direction, such as with a press. This compresses the o-ring. Make sure that all of the small parts have been inserted prior to closing the end cap.

The probe should be retested and recalibrated anytime it is disassembled and reassembled. Consult your local radiation protection program officer for exact instructions.

4.4 Replacement Parts

Part Number	Description
35-166	GM Tube (1200 CPM/mR/hr)
MSM-1900	Conductive Tape
30-106	MHV Connector
90-5-17	Spring
90-5-3	End Cap

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