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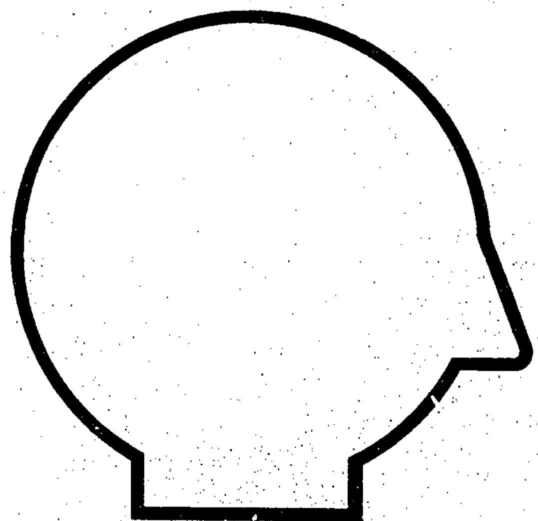
ABSTRACT

This module, one of 25 on vocational education training for careers in environmental health occupations, contains self-instructional materials on using ionizing radiation detectors. Following guidelines for students and instructors and an introduction that explains what the student will learn are three lessons: (1) naming and telling the function of the major components of a geiger counter, and checking its operation using a sealed check source of low radioactivity: (2) reading a packet ion chamber dosimeter, and recharging the dosimeter using a dosimeter charger; and (3) demonstrating what effects distance, shielding, and time have on radiation levels. Each lesson contains objectives, recommended methods and locations for practice, performance criteria, equipment and supplies to perform a task, detailed step-by-step instructions for learning a task, and performance exercises. Performance tests cover the subject matter of each lesson. (CT)



Using Ionizing Radiation Detectors

Module 11

U.S. DEPARTMENT OF EDUCATION, Office of Vocational and Adult Education

FOREWORD

The Curriculum and Instruction Branch of the Office of Vocational and Adult Education, U.S. Department of Education, identified a need to improve the training opportunities for vocational education students interested in pursuing careers in environmental health. To fulfill that need, Consumer Dynamics, Inc., a Rockville, Maryland, based company, was awarded the contract to develop performance-oriented, competency-based modules in the environmental health sciences.

USING IONIZING RADIATION DETECTORS is one of the modules in the series, "Vocational Education Training in Environmental Health Sciences." The module content is based on selected materials in the environmental health field. The module is intended to supplement existing course materials.

CONTENTS

USING THESE SELF-INSTRUCTION MATERIALS

...-instruction learning package or module is designed to ...ch students and instructors flexibility of use. Although intended for use in existing training programs, the ... be used by anyone interested in learning new skills or per... old ones. Therefore, two sets of guidelines are prese... one set addressed to students and the other set addres... o instructors. First, find out how you, the student, should use the materials in this book.

GUIDELINES FOR STUDENTS

Take the Performance Test as a pretest.

When you pick up this book and work through it, your goal will not be a letter grade or a high score on an exam. Instead, you will work to develop skills that you can demonstrate. You will not have to worry about how well someone else is doing. Before you start work on this module, you should be, or have been enrolled, in a course on radiation safety or its equivalent at the 2-year technical-school or college level. To find out if you have sufficient skills to start training, read through the section called PERFORMANCE TEST. If you think you can do all or most of the items in this test, ask your instructor to obtain the necessary equipment and supplies.

Work on parts you need to practice.

If you do everything well, according to the criteria in the Performance Test guidelines, you will not need to spend time working on this module. If after taking the Performance Test you discover there are parts you need to practice, follow the key to each item in FOR FURTHER STUDY.

Work straight through each lesson in the order presented.

Should you decide to completely work through this module, begin with the INTRODUCTION and go straight through each of the three lessons. The lesson begins with the OBJECTIVE of the training. Follow the instruction for each part in the order presented. Practice each step in a lesson until you can do it according to the criteria stated for the step. At the end of a lesson, do the EXERCISES. When there are audiovisuals listed at the end of a lesson, ask your instructor for help in obtaining them.

Take the Performance Test as a posttest.

Finally, after you have mastered all of the exercises in each lesson, ask your instructor to watch you do each item in the Performance Test. The items in the Performance Test are intended for use as a posttest to evaluate the quality of your performance. Turn now to the Performance Test.

GUIDELINES FOR INSTRUCTORS

Approach

The approach of these materials is to provide the student with the opportunity to apply basic skills in operating a geiger counter, and for reading and charging a pocket ion chamber dosimeter to demonstrate the effects of distance, shielding, and time on the level of radiation. The equipment and check sources available to you may be different from those presented in the lessons. If such is the case, you may need to write supplementary instructions to point out those differences. The skills tested in the Performance Test are designed for use with equipment similar to that used in the lessons.

Use of the Performance Test

A Performance Test is provided to serve as a guide to the skill development progress. If a student is able to demonstrate skill development by meeting the criteria for performance given in each test item, further study is not needed. Therefore, the student should be given the option of entering training at any point. To determine at what point to start, the student should also be allowed to test out of the remaining portions of training.

Also, the student's capability to accurately complete the entire task in a timely manner can be evaluated by using the Performance Test as a posttest.

Teaching Approaches

This module is designed to enable the student to work independently under whatever time constraints you deem reasonable. However, depending on the skill level of the students with whom you are working, you may find it desirable to start a group together at the same time with a demonstration and informal presentation on the contents of the module. Alternatively, you may choose to use this module as a laboratory workbook in a structured laboratory session. With this option, you allow students greater access to your assistance.

General Instructions

Read through each lesson to anticipate what equipment and supplies you will need to make available for students to use. Also order any audiovisuals or reading materials you think may present a complementary perspective to the training in this module.

Specific Instructions

The radiation detection instruments discussed in the lessons are readily available in Civil Defense (CD) organizations, and there are literally thousands of the instruments in use in CD offices around the country. While these units are not as sophisticated as those used by professional health physicists, the principles of operation are the same. Due to the availability of these instruments, you will probably have little difficulty in being able to borrow a few from your local CD office.

Be sure to check with a local representative of the Nuclear Regulatory Commission (NRC) on the licensing requirements for all check sources you use.

In Lesson Three are presented specific radioactive emission data. These data were calculated by using the following basic formula* that applies to gamma emitters only:

$$R/hr/1\ ft = 6\ CE$$

where: R = roentgens
C = curie strength
E = energy of the source

Since a 10-microcurie cobalt-60 check source is commonly used, mR/hr emitted from this source was calculated:

If $C = 1 \times 10^{-5}$ curies and $E = 2.4$ MeV, then:

$$mR/hr = 6 \times (1 \times 10^{-5}) \times 2.4 \times (1 \times 10^{3}) = 0.144$$

The following table was generated, using a formula based on the INVERSE SQUARE LAW:

$$\left(\frac{1}{\frac{D - d_n}{D}}\right)^2 \times 0.144\ mR/hr$$

where: D = 12 inches
d_n = 1-inch increments

12"	0.144 mR/hr	6"	0.576 mR/hr
11"	0.171	5"	0.829
10"	0.207	4"	1.296
9"	0.256	3"	2.304
8"	0.324	2"	5.184
7"	0.423	1"	20.736

*Olishifski, J.B. (ed.), Fundamentals of Industrial Hygiene. National Safety Council, Chicago, IL, 1971.

BACKGROUND

Research laboratories, hospitals, and industrial plants use radioactive sources and devices in a wide range of applications. Many of these radioactive materials emit particles that are capable of penetrating and destroying the molecular matter in cells through ionization. The destruction of cells by radioactive particles can cause health-related problems when exposure to such materials is prolonged or when exposure is to large amounts for only a brief period. But scientists have learned how to use small quantities of many of the radioactive materials known as isotopes in medical treatment and research, and as tracers to track defects in industrial goods and in the operation of equipment.

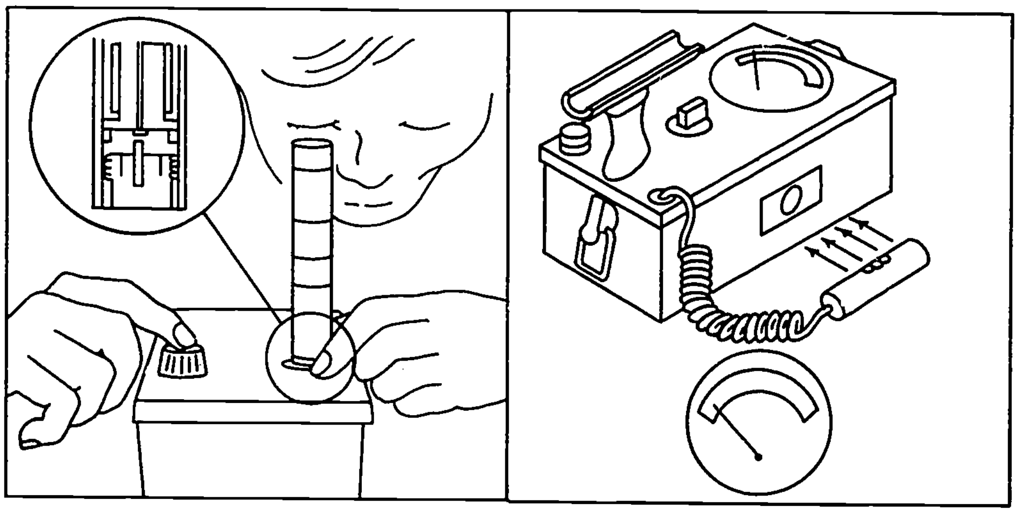
Accidental exposure to radioactive substances can occur in situations in which control of the material is lost or compromised. An example of such a situation occurs whenever liquids containing radioactive substances are spilled. To prevent accidents, very strict controls are placed on the handling and use of radioactive substances by State and Federal agencies.

When accidents do occur or when emergencies arise in which radioactive materials are involved, two instruments presented in this module are commonly used: the geiger counter and the pocket ion chamber dosimeter. Because of their direct-reading capabilities, both instruments are basic to any radiation protection program. Geiger counters are primarily survey instruments used to detect the presence and strength but not the amount of radioactivity, and the pocket ion chamber dosimeter allows measurement of an individual's accumulated exposure. The pocket ion chamber dosimeter is used when "same day" dose data are needed.

Although long-duration exposure to high levels of radiation can be hazardous, there are certain control measures that are employed to reduce or eliminate the hazard. The three most common controls are distance, shielding, and time. You will perform demonstrations in the following lessons that will enable you to gain a working knowledge of the basic concepts associated with these terms.

WHAT YOU WILL LEARN

When you finish working through the steps and exercises in this module, you will be able to operate a geiger counter and read a pocket ion chamber dosimeter in demonstrating how radiation levels are affected by distance, shielding, and time.



You will learn how to perform these functions in three lessons:

o Lesson One

You will be able to name and tell the function of the major components of a geiger counter, and to check its operation using a sealed check source of low radioactivity.

o Lesson Two

You will be able to read a pocket ion chamber dosimeter, and to recharge the dosimeter using a dosimeter charger.

o Lesson Three

You will be able to demonstrate what effects distance, shielding, and time have on radiation levels.

OBJECTIVE

You will be able to name and tell the function of the major components of a geiger counter, and to check its operation using a sealed check source of low radioactivity.

WHERE AND HOW TO PRACTICE

You should practice this lesson on a worktable that is approximately 3 feet by 6 feet. Read through each step before attempting to do it, and make sure you can perform the steps as well as described in "How Well You Must Do."

HOW WELL YOU MUST DO

You must be able to correctly label all drawings in the exercises within 5 minutes, without referring to notes or instruction materials. You must be able to perform an operational check on the instrument within 5 minutes without referring to notes, and be able to determine what value is indicated when the meter needle points to a scale reading that lives between scale markings.

THINGS YOU NEED

You will need the following equipment to work through this lesson:*

- o geiger counter, Victoreen CDV-700 (0-300 counts per minute) or equivalent
- o "D" size batteries, 4 for the Victoreen CDV-700
- o hermetically sealed check source, such as a 10-microcurie cobalt-60 source.**

Instructions: Now turn to the next page and begin work on Lesson One, "Getting There--Steps."

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*Presentation of equipment is not intended to be an endorsement by the U.S. Department of Education of a specific make or model.

**Sources that do not require an NRC license are available from: Eberline Instruments, P.O. Box 2108, Santa Fe, NM 87501; and Victoreen Nuclear Associates, 10101 Woodland Ave., Cleveland, OH 44104.

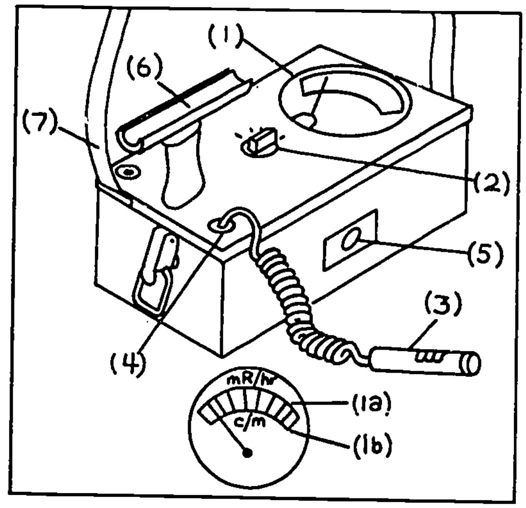
GETTING THERE--STEPS

STEP 1

Place the geiger counter on the table in front of you. Using the drawing in the Key Point, identify the following:

- two-scale meter display (1) to indicate level of radioactivity in milliroentgens per hour (mR/hr) (1a), and counts per minute (C/M) (1b)
- range selector switch (2) to select X1, X10, and X100 ranges
- the Geiger-Mueller (GM) tube holder or probe for detecting radioactivity (3)
- GM probe connector to link the probe with the instrument's internal electronic circuitry (4)
- check source, containing a small amount of depleted radioactive material, usually uranium (5)
- carrying handle (6)
- over-the-shoulder carrying strap (7).

KEY POINT 1



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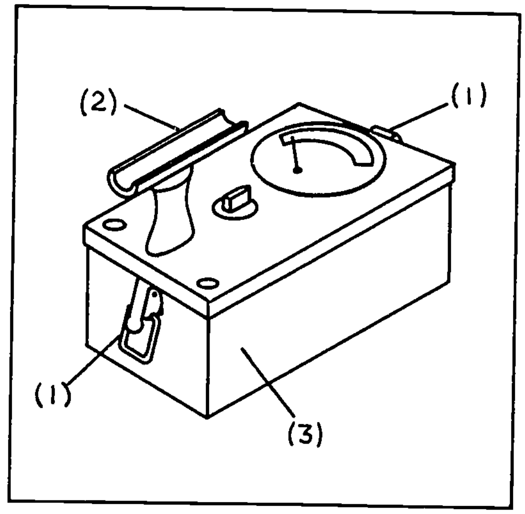
STEP 2

To install the batteries, first open the case by releasing the two case access snaps (1). Hold the carrying handle (2) while pulling the case (3) down.

KEY POINT 2



To install batteries, first remove the case.

STEP 3

On opening the case, check the polarity markings on the battery holders. When installing the batteries, match the polarity markings on the batteries with those on the holders. Replace the case and secure the snaps.

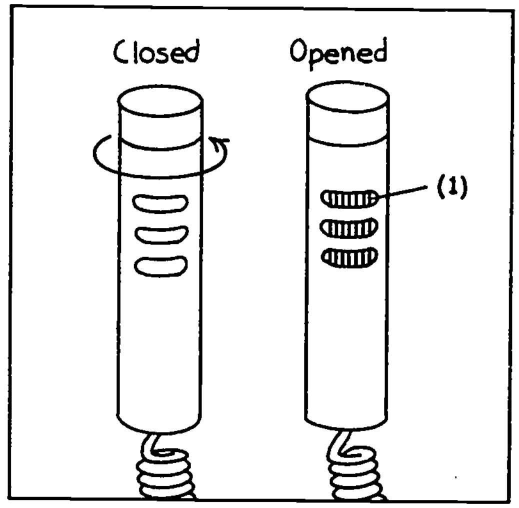
KEY POINT 3

Observe polarity markings when installing the batteries.

STEP 4

Remove the GM probe from the carrying handle. As shown in the Key Point, rotate the outer jacket of the GM probe by twisting it. This exposes the radioactive-sensing element(1).

KEY POINT 4

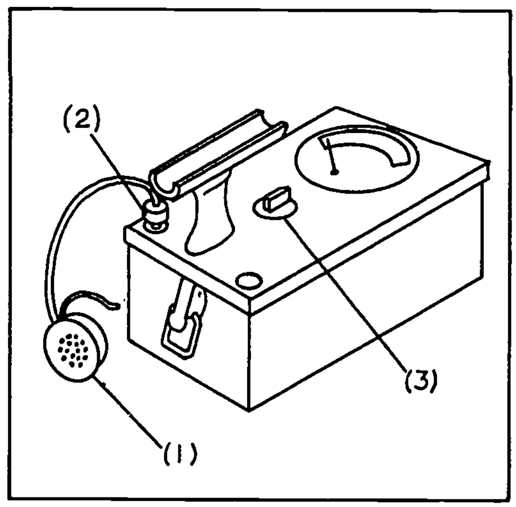


Twist open the GM tube.

STEP 5

Connect the earphone (1) to the earphone connector (2) to hear the clicking sound of detected radioactivity. Turn the range selector (3) to the X1 scale. When measuring a source of an unknown radiation level, start at the lowest (most sensitive) measurement scale. Place the earphone on your ear.

KEY POINT 5

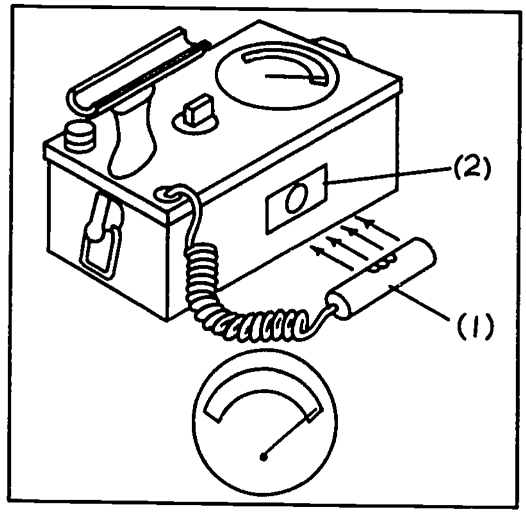


Use the earphones to hear the clicks of radioactivity being detected.

STEP 6

Move the GM probe (1) close to the check source (2) on the side of the case. Turn the probe so the side with the open holes faces the instrument case. The needle should read full scale or greater, and the clicking should seem very rapid.

KEY POINT 6

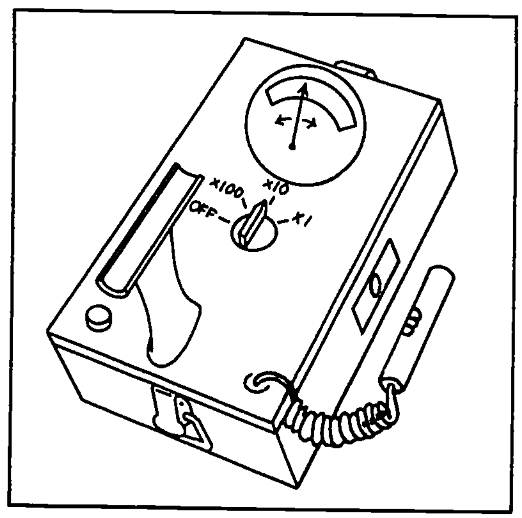


Use the check source to test instrument operation.

STEP 7

Turn the range selector switch to the X10 setting while holding the GM probe close to the check source. You should hear a decrease in the clicking sound and see the needle fall 20 or 50 percent of full scale.

KEY POINT 7



At the X10 setting, the clicking should decrease, and the needle should move to the halfway point on the scale.

STEP 8

While still holding the GM probe, switch the range selector to the highest or X100 setting. You may or may not hear any clicking, and the meter needle may or may not indicate a reading.

KEY POINT 8

The instrument is least sensitive to radioactivity at the highest setting.

STEP 9

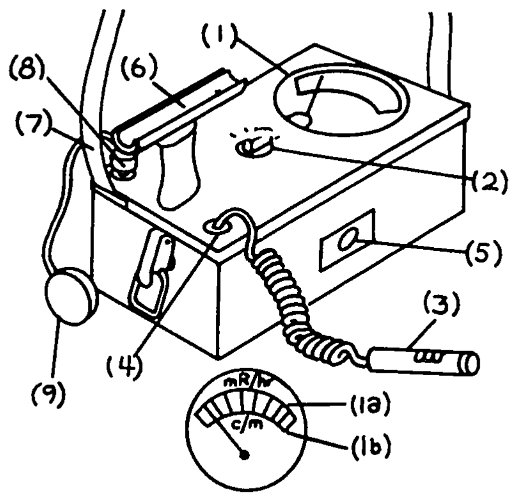
If you obtained the results described in Steps 6 through 8, you have verified that the GM probe, internal electronics, audio circuitry, and the display meter are functioning properly. Perform these checks prior to making a set of measurements.

KEY POINT 9

Before operating the geiger counter, use the check source to test its functions.

EXERCISES

Instruction 1: Referring to the equipment and/or drawings in the lesson, label the following drawings. You must be able to name each part in the drawing and tell how it functions or is used. You should be able to do this in 5 minutes or less.



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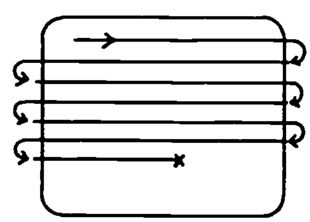
Instruction 2: Obtain a low-radioactive, sealed check source from your instructor; a large piece (2 feet by 3 feet) of 1/16- or 1/32-inch-thick cardboard; an empty box with an opening a little smaller than the piece of cardboard; and a roll of masking tape. To best do this exercise, work with another person. While you are looking away, have the person tape the source to the cardboard and place it source down over the empty box. Set the range selector switch on the geiger counter to X1. While holding the GM probe horizontally about 2 inches above the cardboard, move the probe across the cardboard, starting at the edge and proceeding in a straight line. Follow the pattern shown in this diagram to search for the source:



When you have found the source, obtain the highest possible reading by setting the range selector on the position providing the greatest sensitivity to maximize the probability of discovering the source on the first pass.

Instruction 3: Have your instructor or the person you are working with hide the sealed check source in another part of the room. Locate the source, using a systematic search pattern.

OTHER READING

Radiation Hygiene Handbook, Blatz, H. McGraw-Hill Book Company, Inc., 1959.

General Handbook of Radiation Monitoring (L.A. 4400), Superintendent of Documents, Washington, DC. (no date)

FILMS AND SLIDE/TAPE PROGRAMS

U.S. Nuclear Regulatory Commission. "An Added Sense--The Detection of Nuclear Radiation," 1973.

This 25-minute, 16-mm film (optional sound, color) presents significant concepts associated with radiation detection technology, such as the various forms of radiation, gas ionization counters, and several unique methods, including thermoluminescence. (Available for $145.00 from the National Audiovisual Center, Washington, DC 20409. Title No. 003512/RL.)

OBJECTIVE

You will be able to read a pocket ion chamber dosimeter, and to recharge the dosimeter using a dosimeter charger.

WHERE AND HOW TO PRACTICE

Continue using the area you selected for practicing Lesson One. Before working on any of the steps and exercises, carefully read each one. If you have any questions about how to perform any step in this lesson, request help from your instructor.

HOW WELL YOU MUST DO

You must be able to name, identify, and explain the purpose of all the major components of both the dosimeter and charging unit. You must also be able to read the exposure level indicated in the reticle, and determine when the dosimeter is fully charged and ready for use.

THINGS YOU NEED

You will need the following equipment* and supplies to work through the steps and exercises in this lesson:

- o pocket ion chamber dosimeter, 0-200 mR range dosimeter such as the Eberline Model 862, Dosimeter Corp. of America, Type 862; or Victoreen Model 541L
- o dosimeter charger for direct-reading dosimeters, such as the Victoreen Model 2000A Charger, or Eberline Model 909
- o dosimeter calibrator, such as the Victoreen Model 06-200 with a 90-microcurie Cesium-137 sealed source.**

Instructions: Now turn to the next page and begin work on Lesson Two, "Getting There--Steps."

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*Presentation of equipment is not intended to be an endorsement by the U.S. Department of Education of a specific make or model.

**Source requires NRC or Agreement State licenses.

GETTING THERE--STEPS

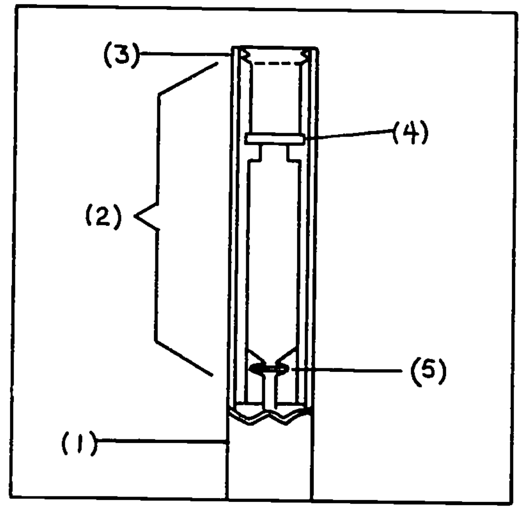
STEP 1

Place the pocket ion chamber dosimeter in front of you. Use it and the drawing in the key point to identify the following:

- o hermetically sealed protective barrel (1)
- o microscope (2), comprised of a microscope eyepiece (3) to enable the user to see the reticle (4) containing the milliroentgen scale. The hairline cursor is projected onto the reticle through the objective lens (5).

Pick up the dosimeter. While holding it up to a light source, look through the microscope eyepiece to see what reading is registered on the reticle. Each index line on the scale represents 10 mR if you are looking through a dosimeter whose scale is graduated from 0 to 200 mR. Place the dosimeter aside.

KEY POINT 1



The dosimeter microscope enables the user to read the hairline on the reticle.

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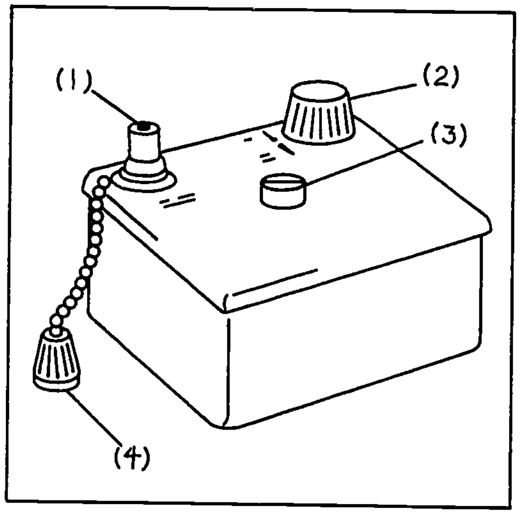
STEP 2

Place the dosimeter charger in front of you, and identify the following:

- o contact assembly (1).
- o scale adjust control (2)
- o case assembly retaining screw (3) (This may be on the bottom of the unit.)
- o contact assembly protective cap (4).

KEY POINT 2

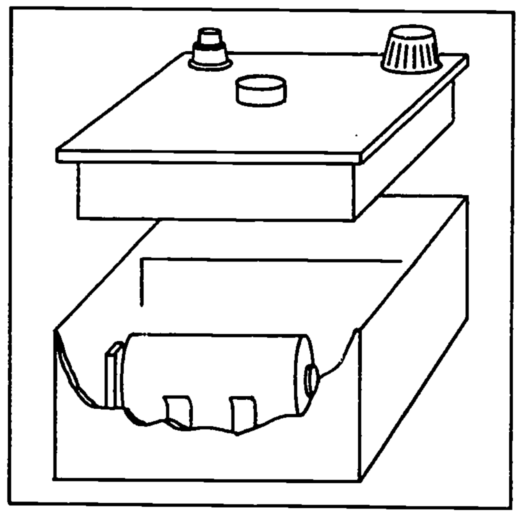


Use the dosimeter charger to zero the pocket ion chamber dosimeter.

STEP 3

Check to see that a battery has been installed in the charger. Loosen the case assembly retaining screw and pull the top and bottom of the charger apart. When placing the battery in the battery holder, match the polarity markings. Put the charger case back together and tighten the retaining screw.

KEY POINT 3

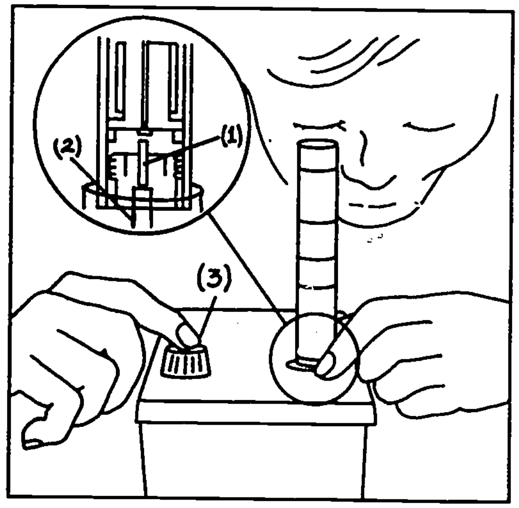


Separate the top and bottom of the charger in order to install the battery.

STEP 4

Place the dosimeter lightly on the charging contact. Make sure the charging pin (1) and charging contact (2) fit together. If the charging unit you are using features a read function, you can read the reticle, using the charger's built-in light source. To read the dosimeter, push down on the adjust control (3) while you look into the eyepiece. Note the reading under the hairline.

KEY POINT 4

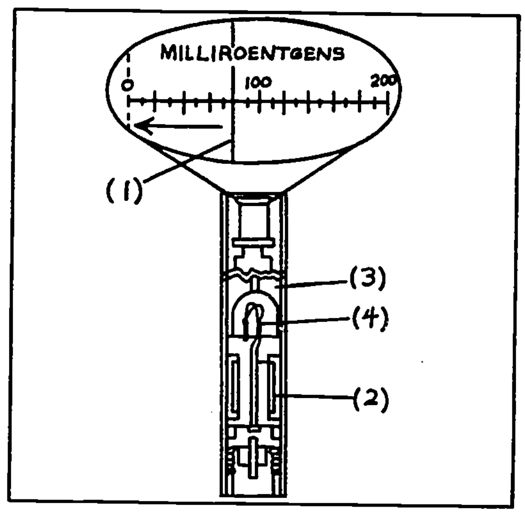


If the charging unit has a read function, place the dosimeter lightly on the charging contact and push the adjust control.

STEP 5

To reuse the dosimeter after a reading is obtained, it must be recharged. When the dosimeter is recharged, the hairline moves to zero. Place the dosimeter on the charging contact as you did in Step 4, except press it down. Look into the eyepiece. You should see the hairline (1); if you do not, rotate the adjust control until it appears. Turn the adjust control until the hairline is lined up with the zero point. The capacitor (2) stores the charge until ionizing radiation enters the ionization chamber (3). The charge is decreased in proportion to the exposure, and registered by movement of the quartz fiber electrometer (4).

KEY POINT 5

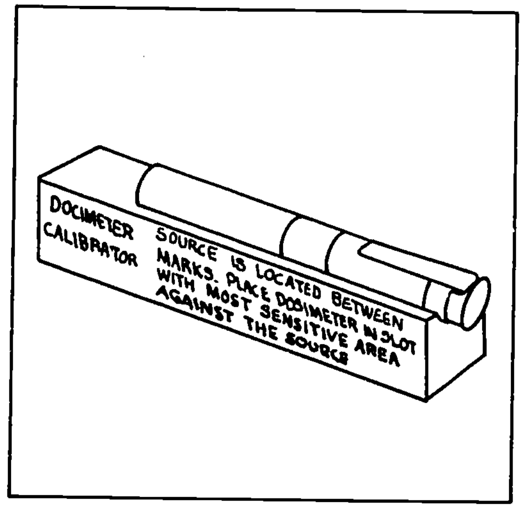


Zero the dosimeter by recharging.

STEP 6

In this step, you will check the operation of the dosimeter by placing it in a dosimeter calibrator. However, before handling the calibrator, READ THE MANUFACTURER'S INSTRUCTION MANUAL! Ask your instructor about any precautions you should follow for handling the calibrator. Leave the dosimeter in the calibrator for the specified length of time; then read it, using the charger or another light source. If you use the Victoreen Model 06-200 dosimeter calibrator, you should be able to read 35 to 45 mR in 15 minutes.

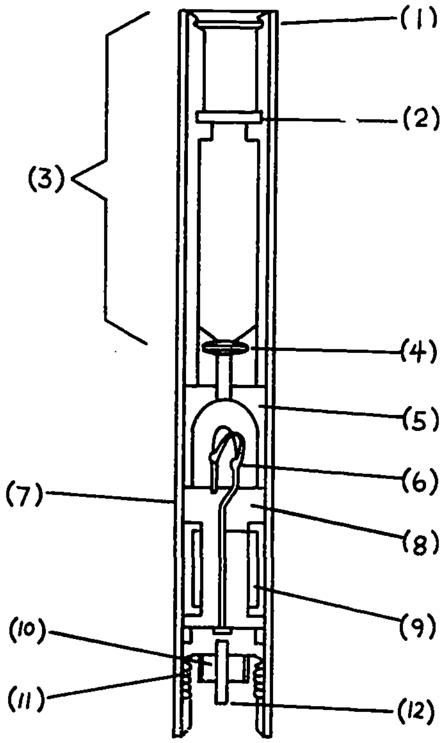
KEY POINT 6



Use the dosimeter calibrator to make an accurate determination of whether the dosimeter is operating properly.

EXERCISES

Instruction 1: Correctly label each of the following parts of the dosimeter and charging unit. Write a brief explanation of how the parts function in the spaces provided.



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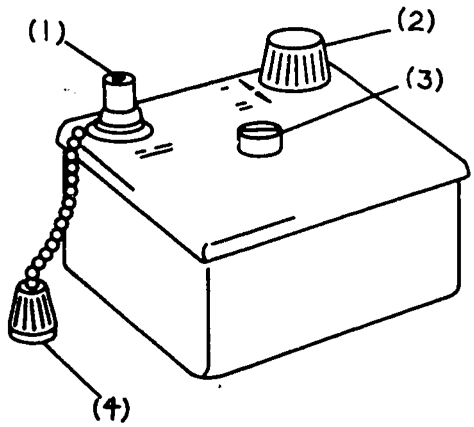

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Instruction 2: Using the dosimeter calibrator, expose the dosimeter for longer perious of time. If the manufacturer's recommended exposure time is 15 minutes, expose the dosimeter for 30, 45, and 60 minutes. Read the dosimeter after each exposure period, but DO NOT REZERO THE DOSIMETER AFTER EACH PERIOD. The object of this exercise is to see what effect TIME of exposure to a fixed amount of radiation has on the dosimeter. Record your exposure results in the chart provided.

TIME	15 min	30 min	45 min	60 min
EXPOSURE (in mR)				

What is the effect of increased time exposure? Write an explanation here:

____

____

____

____

OTHER READING

Cameron, Suntharlingam, and Kenney. Thermoluminescent Dosimetry, University of Wisconsin Press, Madison WI, 1968.

General Principles of Monitoring Radiation Protection of Workers, ICRP Publication No. 12, Elmsford, NY, Pergamon Press, 1969.

Code of Federal Regulations, Title 29, Part 1910.96, Ionizing Radiation.

Direct and Indirect Reading Pocket Dosimeters for Xand Gamma Radiation Performance, Specifications for ANSI N 13.5-1972.

OBJECTIVE

You will be able to demonstrate what effects distance, shielding, and time have on radiation levels.

WHERE AND HOW TO PRACTICE

Work through the steps and exercises in this lesson in the same location as in previous lessons. Before working through any part of this lesson, read the entire lesson. Have available instructor's manuals on the geiger counter, dosimeter, charging unit, and dosimeter calibrator, and obtain from your instructor any special instructions on the use of the check sources you will be using. If you have any questions about how to perform any part of the lesson, request help from your instructor.

HOW WELL YOU MUST DO

You must be able to position the GM probe and pocket ion chamber dosimeter within $\pm 1/4$ inch of the locations specified in the lesson. You must also be able to demonstrate that the relationship between the level of radiation and

- o DISTANCE follows the inverse square law for point sources of ionizing radiation;
- o SHIELDING is proportional to thickness of the barrier material; and
- o TIME is directly proportional.

Note: The calculations of mR in this lesson are based on the use of a 10-microcurie Co-60 check source. If this source is not available, your instructor will need to furnish other calculations that match the check source that is available.

THINGS YOU NEED

In addition to the equipment and supplies you used in the previous lessons, you will need the following:

- laboratory ringstand
- adjustable clamp sized to hold the GM probe
- adjustable clamp sized to hold the pocket ion chamber dosimeter
- two 6-inch-square, 1/4-inch-thick pieces of lead
- tape measure or ruler
- clock or stopwatch for timing 10-minute intervals.

Instructions: Now turn to the next page and begin work on Lesson Three, "Getting There--Steps."

GETTING THERE--STEPS

STEP 1

Test the effect of DISTANCE. First, place the GM probe in the clamp so the probe holes are face down. Tighten the clamp, and position it on the ringstand approximately 6 inches above the ringstand base as shown in Key Point 2.

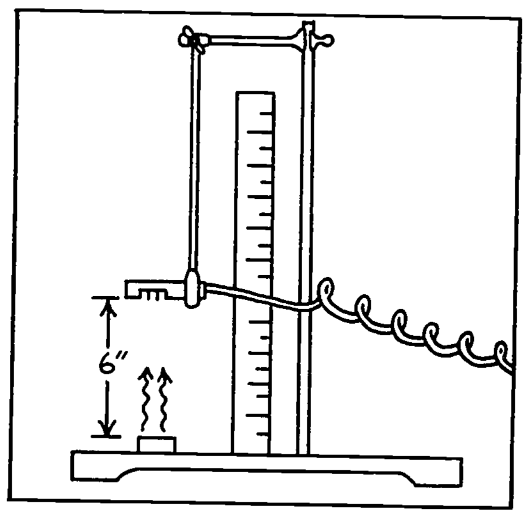
KEY POINT 1

Position the GM probe on the ringstand 6 inches above the base.

STEP 2

Place the source on the ringstand. Measure the height of the source and record that measurement here:__________. Loosen the clamp holding the GM probe and adjust the height to 6 inches ±1/4 inch plus the height of the source. Set the range selector switch on X10 and open the jacket on the GM probe. Read the scale to the nearest 0.05 mR/hr. Record that measurement here: __________mR/hr. Your reading should be within ±10 percent of 0.6 mR/hr.

KEY POINT 2



With the GM probe at 6 inches, make a measurement to within 0.05 mR/hr on the X10 setting.

STEP 3

Loosen the clamp holding the GM probe. Adjust it so the probe is 12 inches ±1/4 inch above the source. Set the range selector switch on X1 and read the scale to the nearest 0.005 mR/hr. Take a reading and record it here: ________ mR/hr. Your reading should be within ±10 percent of 0.15 mR/hr.

KEY POINT 3

Take a reading at 12 inches.

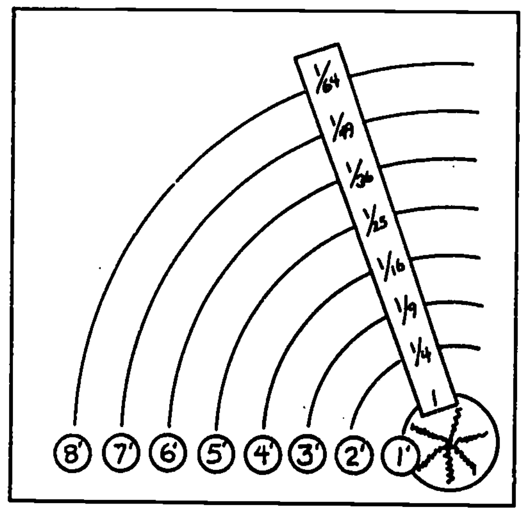
STEP 4

The relationship between the readings in Step 2 and Step 3 follows the INVERSE SQUARE LAW:

- o the radiation level varies indirectly as the square of the distance, or $\frac{1}{D^2}$

When you compare the reading at 6 inches (D_1) with the one at 12 inches (D_2), a doubling of the distance, you will find the radiation level drops by a factor of (1/2) squared, or 1/4. So, 1/4 times 0.6 mR/hr equals 0.15 mR/hr, the reading you obtained at 12 inches. If you made a measurement at 18 inches, a trebling of the distance, the radiation level should drop by a factor of (1/3) squared, or 1/9, and the reading should be 0.07 mR.

KEY POINT 4



The effect of DISTANCE on radiation exposure follows the inverse square law.

STEP 5

Lower the GM probe so that it is 2 inches ±1/4 inch above the check source. Set the range selector to X100 and read the scale. Record the radiation level here: ________ mR/hr. Your reading should be within ±10 percent of 5.18 mR/hr.

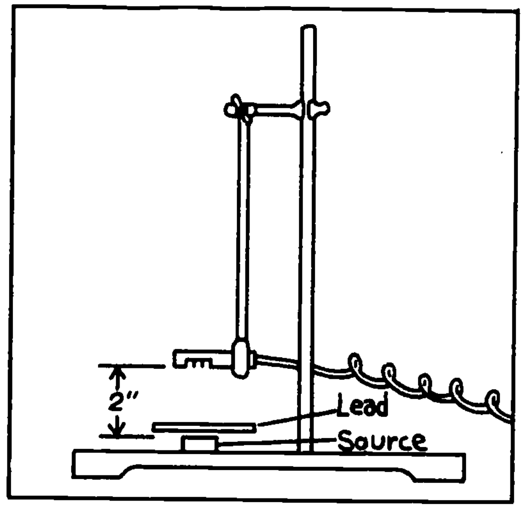
KEY POINT 5

Take a reading with the GM probe positioned 2 inches above the source.

STEP 6

Test the effect of SHIELDING. Place the piece of lead on top of the source. With the range selector set at X10, take a reading. Record it here: ______. The half-value layer (HVL)* of lead is 0.25 inches. Since this thickness was used, the reduction in the radiation level in Step 5 should be (5.184 mR/hr)/2 or 2.59 mR/hr.

KEY POINT 6



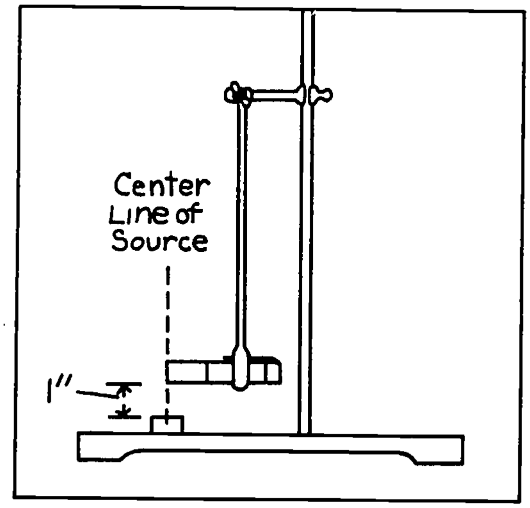
A 1/4-inch-thick piece of lead will reduce radiation from the source by half.

*The thickness of a material sufficient to decrease the radiation level by half.

STEP 7

Turn off the geiger counter. Remove the lead and the source from the ringstand base and set them aside. Unclamp the GM probe and replace it on the instrument holder. Charge and zero the dosimeter as you did in Lesson Two. Place the dosimeter in the clamp and fasten it to the ringstand so the dosimeter is 1 inch above the source. Position the source on the ringstand as shown in Key Point 7.

KEY POINT 7



Clamp the dosimeter 1 inch above the source.

STEP 8

Test the effect of TIME. Start timing a 10-minute period. After 10 minutes, remove the dosimeter from the clamp and read the radiation level as you did in Lesson Two. Record the reading here:________ mR. Your reading should be within ±10 percent of 3.5 mR. Repeat this step five more times to obtain a total exposure time of 60 minutes. Fill in the blank spaces after you read the dosimeter (the mR shown is the expected reading). Do not zero the dosimeter until after making the final reading.

20 min (7 mR) ________mR

30 min (10.5 mR)______mR

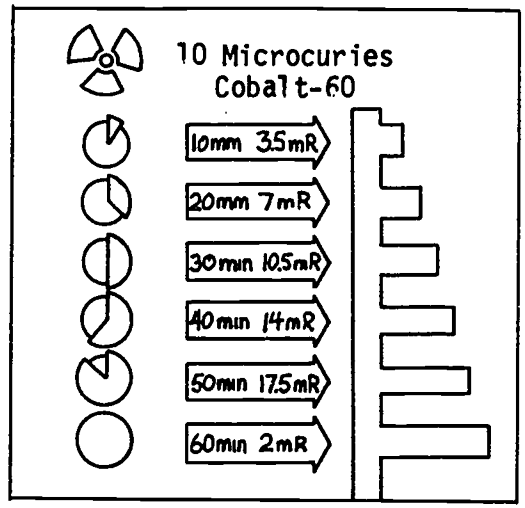
40 min (14 mR)________mR

50 min (17.5 mR)______mR

60 min (21 mR)________mR

This step illustrates that the longer you are exposed to radiation, the higher will be the amount of radiation you receive.

KEY POINT 8



For each succeeding 10-minute period of additional exposure another 3.5 mR accumulates; after 60 minutes the dosimeter reading should be about 21 mR.

EXERCISES

Instruction 1: In Step 4 the reduction in the radiation level was calculated to be 0.07 mR/hr if the GM probe was first located at 3 inches from the source and then moved to 12 inches. Repeat Steps 1 through 4 and obtain a measurement. How does your measurement compare with the calculation? ____________________

____

Calculate what reading you should obtain when the GM probe is located at 4 inches and then when moved to 16 inches. Show the calculation below:

Repeat Steps 1 through 4 and prove your calculation.

Instruction 2: In Step 6 you measured the effect of shielding by placing a 1/4-inch piece of lead over the source. Repeat Steps 5 and 6, but this time place two 1/4-inch pieces of lead over the source. Record your measurement here: ________ mR/hr. You should have observed a reading of 1.30 mR/hr (±10 percent). If the reading of the uncovered source at 2 inches was 5.18 mR/hr, then adding two half-value layers is the same as:

$$5.18 \text{ mR/hr} \times 1/2 \times 1/2 \text{ or } 5.18/4 = 1.30 \text{ mR/hr}$$

FILMS AND SLIDE/TAPE PROGRAMS

"Physical Principles of Radiological Safety." Available from the Audiovisual Support Center, Armed Forces Institute of Pathology, Washington, DC 20306. This is a 16-mm, sound, black-and-white movie, 51 minutes long.

"Practical Procedures of Measurement (Radioisotopes)." Available from the Audiovisual Support Center, Armed Forces Institute of Pathology, Washington, DC 20306. This is a 16-mm, sound, black-and-white movie, 48 minutes long.

PERFORMANCE TEST

Instructions: Check your skill level or progress by working through each of the items in this test. If you can perform each item as required, place a check in the space provided. When all of the items are checked, you are ready to demonstrate your skills to your instructor. You will be considered trained in a skill after your instructor approves your performance of each of the following items:

OPERATING A GEIGER COUNTER

No. 1____ Name, point out, and describe the major components of the geiger counter.

No. 2____ Observe polarity when installing batteries in the geiger counter.

No. 3____ Check the operation of the geiger counter with the range selector switch set on X100.

No. 4____ Check the operation of the geiger counter with the range selector switch set on X10.

No. 5____ Check the operation of the geiger counter with the range selector switch set on X1.

FOR FURTHER STUDY

If you could not perform one or more of the five items above, review and practice the following lesson steps:

No. 1
Lesson One, Step 1

No. 2
Lesson One, Steps 2 and 3

No. 3
Lesson One, Steps 4 through 6

No. 4
Lesson One, Step 7

No. 5
Lesson One, Step 8

READING A POCKET ION CHAMBER DOSIMETER

No. 1_____ Read three values of exposure that have been "dialed in" on a dosimeter by your instructor, using the dosimeter charger.

No. 2_____ Observe polarity when installing the battery in the dosimeter charger.

No. 3_____ Zero the dosimeter, using the dosimeter charger.

No. 4_____ Check the dosimeter calibration, using a dosimeter calibrator.

FOR FURTHER STUDY

If you could not perform one or more of the four items above, review and practice the following lesson steps:

No. 1
Lesson Two, Steps 1 and 2

No. 2
Lesson Two, Step 3

No. 3
Lesson Two, Steps 4 and 5

No. 4
Lesson Two, Step 6

DEMONSTRATING THE EFFECT THAT DISTANCE, SHIELDING, AND TIME HAVE ON RADIATION LEVELS

No. 1_____ Demonstrate how changing the distance between a radioactive source and a geiger counter follows the inverse square law; make measurements that are within ± 10 percent of calculated values.

No. 2_____ Using a geiger counter, a piece of lead, and a radioactive check source, demonstrate the effect one half-value layer of lead has on the level of radiation.

No. 3_____ Using a pocket ion chamber dosimeter and a radioactive check source, demonstrate how time effects the amount of radiation received.

FOR FURTHER STUDY

If you could not perform one or more of the three items above, review and practice the following lesson steps:

No. 1
Lesson Three, Steps 1 through 4

No. 2
Lesson Three, Steps 5 and 6

No. 3
Lesson Three, Steps 7 and 8

REFERENCES

Fundamentals of Industrial Hygiene, Julian B. Olishifiski (ed.), National Safety Council, Chicago, IL, 1979.

Instruction and Maintenance Manual CDV-700, The Victoreen Instrument Company, Cleveland, OH. (no date)

Instruction Manual, Eberline Model 862 Dosimeter, Eberline Instruments, Santa Fe, NM. (no date)

Instruction Manual, Model 862 Dosimeter, Dosimeter Corporation of America, Cincinnati, OH. (no date)

U.S. Department of Health, Education, and Welfare, NIOSH. The Industrial Environment--Its Evaluation & Control, U.S. Government Printing Office, Washington, DC, 1973.