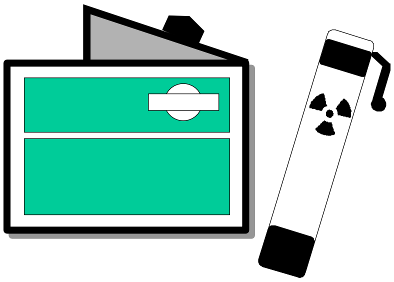
UNIT FOUR

EXTERNAL DOSIMETRY



Unit Three reviewed the biological effects and internal hazards of radiation exposure. You learned about the early and late effects of radiation exposure, the factors affecting radiation damage, the concept of radio-sensitivity, and the pathways of deposition and distribution of radioactive material in the body. Now that you have reviewed the mechanisms of radiation damage and the biological effects of that damage, it is an appropriate time to cover the selection of external dosimetry methods for detecting radiation in emergency response situations.

The radiological emergency responder must monitor his/her total exposure to radiation during the operation. This unit will review the fundamental construction and operation of three commonly used methods of external dosimetry: pocket ionization chambers, film dosimeters, and thermoluminescent dosimeters. The advantages and disadvantages of each dosimeter type will also be covered briefly.

GATE FRAME QUESTION

You have responded to an accident involving a truck containing radiopharmaceuticals packages. The Incident Commander tells you that a package found on the ground indicates that it contains 0.2 Ci of cesium-137 (Cs-137). Cs-137 is a beta and gamma emmitter, with a radioactive half-life of 30 years.

What type(s) of radiation dosimetry device should you be using to monitor your radiation exposure at the site?

____

____

ANSWER

Your answer should include the adjacent information.

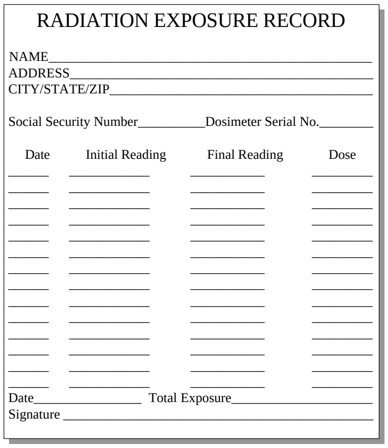
The pocket ionization chamber, film dosimeter (or film badge) and thermoluminescent dosimeter (TLD) would all be appropriate in this situation. Cs-137 is a beta and gamma emitter, and all three of those methods are capable of measuring gamma radiation exposure. The film dosimeter and TLD could also detect beta radiation.

To determine (i.e. read) the total gamma exposure while at the site, the direct reading pocket ionization should be used. None of these dosimeters will effectively detect exposure from inhaled radioactive material.

If your answer included all or most of the above points, you should be ready for the Summary Questions at the end of this unit. Turn to page 4-18.

If your answer did not include these points, it would be advisable for you to complete the instruction for this unit. Turn to page 4-3.

INTRODUCTION TO DOSIMETRY



RADIATION EXPOSURE RECORD

NAME________________
ADDRESS________________
CITY/STATE/ZIP________________

Social Security Number________ Dosimeter Serial No.________

Date	Initial Reading	Final Reading	Dose

Date________ Total Exposure________
Signature ________________

Dosimetry is the monitoring of individuals to accurately determine their radiation dose equivalent. When radiation interacts with the human body, there are no perceptible sensations and usually no immediate effects. We could therefore receive an amount of radiation that could injure our tissues severely without realizing it at the time. To protect ourselves and others, we must use and rely upon instruments to quantify and qualify radiation measurements.

Radiological emergency responders must be able to keep track of their total exposure to radiation during a radiological emergency operation. To do this, an instrument called a *dosimeter* is used. The dosimeter keeps track of the total charges created due to radiation interactions in it. The very same property of radiation that damages human tissues may be used to detect it - ionization. The concept of ionization was explained in Unit Two.

In order to properly use radiation detection instruments, it is essential to fully understand their method of operation. Only a radiological emergency responder who understands the instrumentation and uses it correctly will attain maximum effectiveness from it. The major dosimetry systems used by those involved in radiation work are pocket ionization chambers, thermoluminescent dosimeters (TLDs), film dosimeters, and combinations of systems (TLD plus pocket ionization chambers.)

To test your understanding of these concepts, answer the question on the following page

QUESTION

Circle the correct answer

_______ is the monitoring of individuals to accurately determine their radiation dose equivalent.

a. radiotherapy

b. dosimetry

Turn the page to check your answer.

ANSWERS

a. No, radiotherapy is the use of radioisotopes for medical purposes. Dosimetry involves special radiation detection instruments that measure radiation exposure of individuals using the device.

Try another question.

b. Exactly. You understand the meaning and purpose of dosimetry. During a radiological emergency, responders keep track of their total exposure to with radiation dosimeters.

Move on to the next section.

QUESTION

Circle the correct answer

What property of radiation is utilized by many dosimeters to detect radiation?

a. ionization

b. radioactive half-life

Turn the page to check your answer.

ANSWERS

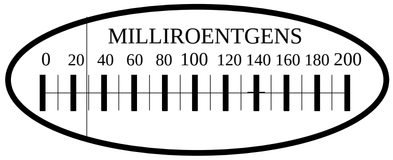
a. Correct. You understand that certain dosimeters keep track of the total charge created due to the ionization created by radiation interactions with matter. Ionization is what also damages human tissue after it has been exposed to radioactive material.

Proceed to the next section.

b. Wrong answer. Recall from Unit Two that radioactive half-life is the time it takes for a radionuclide to decay to one-half of the radioactive atoms that were present at the beginning of the time period. This property is not measured by radiation detection instruments. It is an inherent nuclear property of nuclides. Ionization is the process of removing an electron from an atom, leaving two charged particles. These electrical charges may be detected and measured by the dosimetry system.

Reread page 4-3.

POCKET IONIZATION CHAMBERS



Pocket ionization chambers rely on ionization to detect radiation. A pocket ionization chamber consists of a small, air-filled chamber in which a quartz fiber is suspended. A small microscope and a graduated scale enables one to read the shadow of the quartz fiber. The quartz fiber is displaced by charging it with about 200 volts; at this point, the dosimeter scale reads 0. Exposure to radiation discharges the fiber by creating ions; the dosimeter scale then reads that amount of ionization.

There are various types of pocket ionization chambers. Some are direct, or self-reading, while others are indirect, or nonself-reading. There is also a variety of pocket ionization chambers that read at different rates (0.01-200 mR and 1-500 R). Pocket ionization chambers, *primarily* measure whole body gamma exposure (with some x-radiation).

There are several advantages to using pocket ionization chambers.

- A cumulative exposure can be read at any time or location without ancillary equipment.
- The chambers can be used repeatedly by simply recharging or rezeroing.
- They have a long shelf-life with little to no maintenance requirements.
- The individual can directly read his/her exposure.
- Pocket ionization chambers measure gamma exposure accurately.
- They are sealed at the time of manufacture and are relatively insensitive to environmental conditions.

There are also possible disadvantages to the use of pocket ionization chambers.

- The exposure readings on the devices may be sensitive to a significant mechanical shock (for example, if dropped more than a few feet to a concrete surface).
- The initial cost of a pocket dosimeter is high.

Let's pause now and test your comprehension of how pocket dosimeters operate.

QUESTION

Circle the correct answer

Pocket ionization chambers measure ______ radiation exposure.

a. gamma

b. alpha

Turn the page to check your answer.

ANSWERS

a. Yes, pocket ionization chambers primarily measure whole body gamma exposure.

Move on to the next section.

b. No, pocket ionization chambers primarily measure whole body gamma exposure.

Try the next question.

QUESTION

Circle the correct answer

It is important to closely monitor and document your radiation exposure from responding to a radiological emergency. If you are using a pocket ionization chamber, how would you document your exposures?

a. Manually record the exposure readings.

b. Photocopy and store the computer printouts.

Turn the page to check your answer.

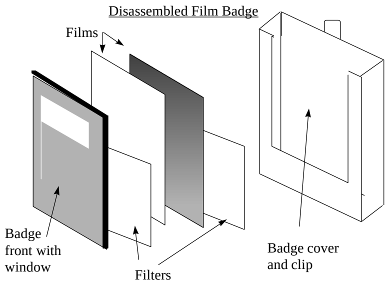
ANSWERS

a. Very good. You remembered that pocket ionization chambers are generally read on site. These exposure readings can and should be recorded on a log. Since there is no printout or film required to get the measurement result, the exposure should be manually recorded at the time of the reading.

You are ready to proceed to the next section.

b. Incorrect answer. There are no computer printouts coming from pocket ionization chambers! Users must manually record the exposure readings.

Review page 4-6.



FILM DOSIMETERS

Film dosimeters, or film badges, consist of layered components. Imagine a sandwich with the following layers starting from the top: the *badge front,* with a window for exposure; *filters* that selectively filter out certain types of radiation; *films* to detect the radiation; more *filters*; then the *badge cover* and *clip* to attach the dosimeter to the individual's clothing.

After a designated period of exposure, the film is taken out of the "sandwich" badge, developed, and read on a *densitometer,* which reads the amount of darkening on the film. The amount of darkening is proportional to the radiation exposure.

There are many advantages to using a film dosimeter for personnel monitoring.

- The dose measurements for various film badges range between 10 mrem to 1500 mrem for gamma and x-radiation, and 50 mrem to 1000 rem for beta radiation.
- Film badges can distinguish between penetrating radiation (high, medium, and low photon energies) and non-penetrating radiation (beta and x-ray radiation less than 20 keV).
- Film dosimeters are practical because they are small, lightweight, and relatively inexpensive.

There are also possible disadvantages associated with the use of film badges to monitor individual radiation exposure.

- The response of the film to radiation is energy dependent; at energies less than 300 keV, the response tends to increase.
- The films cannot be read immediately.
- Environmental conditions such as heat and humidity will affect the film's response to radiation.
- Film badges may be left or lost at the site of the radiation accident
- They may be contaminated with radioactive materials, which will lead to a false higher result.

QUESTION

Circle the correct answer

Exposure to radiation of the film in the dosimetry badge causes the film to darken. The darkening is proportional to the amount of

a. radiation released at the site.

b. radiation exposure of the individual wearing the badge.

Turn the page to check your answer.

ANSWERS

a. No, the film dosimeter, or badge, cannot measure all the radiation released at the site of the radiological response operation. The badge is only useful for the person wearing it.

Try another question.

b. Correct answer! A densitometer measures the amount of darkening of the film. This amount of darkening is proportional to the amount of radiation exposure of the film.

Move on to the next section.

QUESTION

Circle the correct answer

Film dosimeters are capable of detecting beta, gamma, and x-radiation.

a. True

b. False

Turn the page to check your answer.

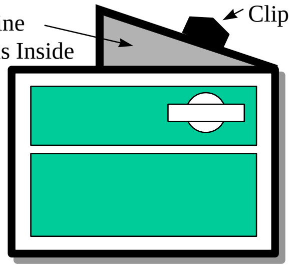
ANSWERS

a. Correct answer. The dose measurements for various film dosimeters range between 10 mrem and 1500 mrem for gamma and x-radiation, and 50 mrem to 1000 rem for beta radiation. Furthermore, film badges can distinguish between penetrating radiation (high, medium, and low photon energies) and non-penetrating radiation (beta and x-ray radiation less than 20 keV).

Proceed to the next section.

b. Wrong answer. The statement is true. Various film dosimeters can measure radiation doses ranging between 10 mrem and 1500 mrem for gamma and x-radiation, and 50 mrem to 1000 rem for beta radiation.

Reread page 4-10.



THERMOLUMINESCENT DOSIMETERS

Thermoluminescence is a property, possessed by certain crystals, of emitting light upon heating after having been exposed to ionizing radiation. The emitted light can be measured. The amount of light is directly proportional to the radiation absorbed dose. Thermoluminescent dosimeter (TLD) badges are issued to radiation workers and emergency responders who have the potential to be exposed to ionizing radiation. The badges are usually issued for use on a monthly or quarterly basis to record the dose received by these personnel from beta, gamma, x-ray , and neutron radiation. Their range of measurement spans anywhere from less than 1 mrem up to as much as 10^5 rem.

There are several advantages to using TLDs for personnel monitoring.

- TLDs can be used with radiation fields of widely varying energy and intensity.
- They can store information for long periods of time without fading.
- TLDs are reusable, and can be used for many applications because of their small size.
- TLDs are less energy dependent than film dosimeters or pocket ion chambers.

There are also some possible disadvantages and problems with TLDs.

- They cannot be analyzed immediately.
- Environmental factors such as humidity and heat may affect the results.

- They may be left or lost at the site of the radiation incident.
- They may be lost, and they may be contaminated with radioactive materials.

To check your understanding of these concepts, answer the following question.

QUESTION

Circle the correct answer

Thermoluminescent dosimeters contain crystals that respond to ionizing radiation and emit ------.

a. radioactive particles.

b. light.

Turn the page to check your answer.

ANSWERS

a. Wrong answer. The crystals *do not* emit ionizing radiation. They measure radiation by emitting light in response to having been exposed to ionizing radiation.

Try another question.

b. Correct. You understand that thermoluminescence is a property possessed by certain crystals. It is the process of emitting light upon heating after exposure to ionizing radiation. The amount of emitted light is directly proportional to the absorbed radiation dose.

Move on to the Summary Question.

QUESTION

Circle the correct answer

One must be cautious with interpreting readings from thermoluminescent dosimeters used during a typical summer day in Florida because

a. of the daily lightning and thunderstorms.

b. the humidity and heat affect the results.

Turn the page to check your answer.

ANSWERS

a. No, unless the thermoluminescent dosimeter is hit directly by lightning, use of this dosimeter should yield relatively reliable readings.

Reread page 4-14.

b. Correct answer. You clearly understand that environmental factors such as humidity and heat may affect the results of thermoluminescent dosimeters.

You may now proceed to the Summary Question.

SUMMARY QUESTION

Complete the following table:

METHOD	TYPE OF RADIATION MEASURED	ONE ADVANTAGE	ONE DISADVANTAGE
Pocket Ionization Chamber			
Film Dosimeter			
Thermoluminescent Dosimeter			

Turn the page to check your answers.

ANSWER

METHOD	TYPE OF RADIATION MEASURED	ONE ADVANTAGE	ONE DISADVANTAGE
Pocket Ionization Chamber	*gamma x-ray*	see page 4-7	see page 4-8
Film Dosimeter	*gamma, x-ray and beta*	see page 4-11	see page 4-12
Thermoluminescent Dosimeter	*gamma, x-ray, beta, and neutron*	see page 4-15	see pages 4-15 and 4-16

Once you are able to complete the chart correctly, move on to Unit 5.