RADIOLOGICAL INSTRUMENTS FOR CIVIL DEFENSE

Your school has received a kit of radiological instruments designed by the Federal Civil Defense Administration. The following instructions and the booklets, which are in the instrument box, are intended to give you guidance in the operation and use of these instruments and are not intended to give guidance as to how they might be utilized in your classroom. In the future, you will receive materials published jointly by the U. S. Office of Education and the Federal Civil Defense Administration which will furnish you guidance on using these instruments in your classroom. In the interim, however, the following information will help you in understanding the function of the instruments.

Included in the kit are instruments which can be divided into two different types depending on the purpose for which each was designed. The first class of instruments, called dosimeters, measures and indicates total accumulated, ionizing-radiation exposure, or, more commonly, total exposure dose. However, the dosimeter cannot be used to measure the radiation a person has received unless it is worn by him during exposure. By keeping records of his dosimeter readings, the wearer can thereby keep track of his total exposure dose. The second class of instruments, called survey meters, measures and indicates the dose rate at the time and place of exposure. These instruments are designed to indicate how fast (or the rate at which) a person is being exposed to ionizing radiation.

The relationships between total exposure dose, dose rate, and time are similar to the relationships between a car speedometer, a car odometer, and time. Let us assume that a driver maintains a speed of approximately

50 m.p.h., as indicated on the speedometer, for a period of eight hours. At the end of this time, the total distance covered, as indicated by the odometer, will be approximately 400 miles. Similarly if an individual enters a radioactive contaminated area where the dose rate, as measured by a survey meter, is 5 roentgens per hour and remains in the area for 8 hours, his total exposure dose, as measured by a dosimeter (assuming no radioactive decay) would be approximately 40 roentgens. However, in all practical cases allowances must be made for the natural decay of the radioactive material.

Each instrument in the kit has a number stamped on its side or top. This number has the prefix CD V. For example, you will find the number CD V-700 on the instruments with the detachable probe. On each instrument you will also find a model number. In the discussion of the theory of operation of the instruments that follows, each instrument will be referred to by its CD V number. However, there will be no attempt to discuss the operation of each model in a particular series of instruments since there is an adequate operational procedure outlined in the instrument manuals which accompany each instrument.

Included in the kit of instruments are two small metal cans labeled CD V-787. The CD V-787 is a harmless radioactive source that will activate the CD V-700 (Geiger Counter). However, the source will not operate the CD V-710 or the CD V-720.

Below is a chart that summarizes the characteristics of the FCDA radiological instruments you have been sent.

Item	CD V-700	CD V-710	CD V-720
Type of detector	Geiger tube	Ion chamber	Ion chamber
Measurement	Dose rate	Dose rate	Dose rate
Units of measurement	Milliroentgens/hr or counts/minute	Roentgens/hr	Roentgens/hr
Kind of radiation detected	Beta and gamma	Gamma	Beta and Gamma
Beta shield	Yes	No	Yes
Range XI	0 - .5 mr/hr	0 - .5 r/hr	0 - 5 r/hr
XIO	0 - 5 mr/hr	0 - 5 r/hr	0 - 50 r/hr
XIOO	0 - 50 mr/hr	0 - 50 r/hr	0 - 500 r/hr
Power source	Batteries	Batteries	Batteries
Battery types	1.5V flashlight (NEDA 13) 45V NEDA 213	1.5 volt, flashlight (NEDA 13) 22½V NEDA 215	1.5 volt, flashlight (NEDA 13) 22½V NEDA 215
Battery life (minimum for continuous operation)	D cells 100 hours B Batt's 100 hours	200 hours	150 hours
Weatherproofed & shockproofed	Yes	Yes	Yes
Audible indication	Yes (earphones or speaker)	No	No
Circuit check	No*	Yes	Yes
Zero adjust	No	Yes	Yes
Calibration source attached	Yes	No	No
Error	± 15% true Co^{60} dose rate	± 20% of true dose rate Co^{60}	± 15% of true dose rate Co^{60}

* However, background count will indicate whether or not the instrument is operating.

Item	CD V-700	CD V-710	CD V-720
Type of use for each instrument	Training, decontamination, operational, personnel monitoring, and food and water monitoring	Training General Area survey Operational Service monitoring Interim aerial survey	High level radiation Area survey Operational Emergency services Fire, police, rescue
Energy dependent	Responds to beta energy above 175 Kev with gamma slightly energy dependent	15% error between 8 Kev and 1.2 Mev	15% error between 8 Kev and 1.2 Mev
Jamming	Yes. If taken into fields greater than 1 r/hr	No	No

Item	CD V-138	CD V-730	CD V-740
Type of detector	Cumulative ion chamber	Cumulative ion chamber	Cumulative ion chamber
Measurement	Dose	Dose	Dose
Range	0-200 milliroentgens	0-20 roentgens	0-100 roentgens
Kind of radiation detected	Gamma	Gamma	Gamma
Power sources	External charger	External charger	External charger
Type of use for each instrument	Training and personnel	Operational	Operational
Weather and shockproofed	Yes	Yes	Yes
Error	+ 10% true dose Co^{60} -	+ - 10% true dose Co^{60}	+ - 10% of true dose for Co^{60}
Leakage	2% full scale/24 hrs	1% full scale/24 hrs	1% full scale 24/hrs
Weight	1½ ounces	1½ ounces	1½ ounces

Principles and Types of
Radiation Measuring Devices

A. PRINCIPLES OF RADIATION DETECTION

1. Radiations are detected and measured by observing their effects on matter.
2. Basis for detection is always ionization.
3. Main classes in general use today:
   a. Photographic emulsions.
   b. Radiophotoluminescence.
   c. Scintillation.
   d. Chemicals.
   e. Enclosed volume of gases: the only practical method used in instruments under major FCDA procurement.
4. Description of each principle of detection in the above classes.
   a. Photographic emulsions. Interaction of radiation with the silver halide in the emulsion causes ionization which forms a potential image. Development of the film converts this potential image black deposits of metallic silver. The degree of darkening is related to the amount of radiation exposure.
   b. Radiophotoluminescence (phosphate glass). The amount of radiation exposure is proportional to the fluorescence under ultraviolet light.
   c. Scintillation. Ionization in the crystal produces a flash of light. The light is converted to electrical current by the photo-multiplier tube and the electrical current is amplified.
   d. Chemicals. Ion pairs produced by radiation combine chemically to form new compounds or change chemical characteristics from those existing before being exposed to radiation.

e. Enclosed volume of gases. In passing through a gaseous medium radiation loses energy by ionizing the gas molecules. The amount of radiation exposure can be determined by collecting and measuring the charge associated with these ionized particles.

B. DOSIMETERS

1. Most practical kind is the electrostatic, which is a cumulative ion chamber.

2. This dosimeter is basically an electroscope.

3. The electrostatic dosimeter and how it functions.

a. A parallel supporting rod is at the same voltage as the fiber. It repels the fiber in the same way leaves of the electroscope repel each other.

b. Collection of ions from the chamber reduces the charge on the fiber. This reduces the electrostatic force on the fiber and it starts to return to the uncharged position.

4. Dosimeters measure total radiation exposure dose rather than dose rate.

5. The FCDA dosimeters are designed so the scales read in roentgens or milliroentgens directly.

6. Dosimeters measure gamma radiation only.

7. Other dosimeters not currently used in civil defense and their disadvantages:

a. Photographic dosimeters are not self reading, energy dependent, not easily calibrated; temperature dependent. Also they must be developed individually, can be used only once, and have a short shelf life.

b. Phosphate glass dosimeters must be read on a special instrument, are a high range instrument, are not self reading, are radiation dose cumulative.

c. Chemical dosimeters dependent upon color change, are a high range instrument, are energy dependent, have a definite shelf life, and can be used only once.

C. DOSIMETER CHARGER

1. A device to charge the dosimeters to zero.

2. Approximately 180 volts are required to charge a dosimeter to zero.

D. SURVEY INSTRUMENTS

1. Geiger type

a. Operation

(1) A geiger tube is a two-element electronic tube which gives a large, uniform-size current pulse when an ionizing event occurs within its sensitive volume. In essence, it is an electronic amplifier tube which produces the same size pulse regardless of the initial ionizing event.

(2) The output pulse from the geiger tube is fed into an amplifier which in turn activates a speaker or earphone and a metering circuit. Each pulse produces one click in the earphones and represents one ionizing event in the geiger tube. The meter reading is proportional to the number of ionizing pulses occurring per unit time. For average fission product energy of 0.7 Mev gamma radiation, this instrument indicates the intensity of ionizing radiation in milliroentgens per hour.

b. Geiger tubes are often sensitive to ultraviolet light and, therefore, are usually painted black to keep light from entering. Scratches

in this paint covering can allow a response to intense light sources. The earphones enable the monitor to detect small changes in radiation intensity before the meter has a chance to respond.

c. Lowest range and the most sensitive civil defense survey instrument.

2. Ionization chamber type.

a. Operation

(1) Small ionization currents are collected from an enclosed chamber of air.

(2) An electronic circuit is used to amplify the small current.

(3) The amplified output current read on a meter is proportional to the current produced by radiation in the ionization chamber.

(4) The survey instrument is designed for the meter to read directly in roentgens per hour.

(5) The range switch changes the amplification of the electronic amplifier by factors of ten.

b. The CD V-710 measures only gamma radiation. Essentially none of the fallout beta particles can penetrate the instrument case and produce ionization in the chamber.

c. The CD V-720 measures ionization from both beta particles and gamma radiation with the absorbing beta shield open. With the beta shield closed only gamma radiation is measured.

d. Ionization chambers are medium and high range survey instruments. They are not the most sensitive type.

3. Other Survey Instruments not currently used in civil defense.

a. Scintillation counters.

(1) The output electrical current pulse can be used in a circuit similar to that of a CD V-700.

(2) More sensitive than geiger counter, also greater range.

(3) More expensive than other types.

(4) May be used in aerial monitoring.

b. Proportional counters. More expensive and of limited value for civil defense work.

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