Radiological Instruments
Tools for Protecting Against Radiation

Generic Training Package for Response Teams

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07/31/2002
Learning goals

- Identify & Operate Survey and Contamination Meters, Dosimeters, and Dosimeter Chargers.
- Discuss their uses and limitations.
- Provide proper care and maintenance of the equipment.
- Identify and explain special TLD Dosimeters used for tracking personnel exposures.
- Explain the potential use of Potassium Iodide (KI) for Thyroid protection.
- Demonstrate a hands-on capability in the use of Radiological instruments through practical exercises.
The CD V-777 (Modified) Radiation Detection Set
1 ea. CD V-700 Survey Meter for measuring Low level Gamma Exposure Rates and some Beta detection.

1 ea. CD V-715 Survey Meter for measuring high level Gamma / X-Ray Exposure Rates.

1 ea. CD V-700 Count Rate Meter with a Special Pancake probe for improved contamination monitoring.
CDV-777 Modified Set Contents (Cont’d) Dosimetry and Potassium Iodide
Radiological Instruments
Two Types of Information
“Total Exposure” and “Exposure Rate”

DOSIMETER

ODOMETER

METER

SPEEDOMETER
CD V - 700 Characteristics

- **Range:** 0-50 mR/hr Gamma or 0-30,000 CPM Beta plus Gamma Radiation.
- **Visual and Audio indication of Radiation.**
- **Used where incident exposure rates are not likely to exceed 50 mR/h.**
- **Used in tandem with high range CD V-715 Meter.**
- **Refer to FEMA’s Good, Some, None Table for determining response to various RAM’s.**

**Operational Check Source**

**Range Selector Switch**

**Headphone Jack**

**G-M Side Window Probe**
CD V - 700 Characteristics

Probe Window Closed Vs. Probe Window Opened

With the probe window closed **only** Gamma Rays are measured.

Gamma Exposure Rates are reported in **mR/hr.** and relate directly to the degree of the radiation hazard present.

The CDV-700 is calibrated using a Cs-137 Gamma Source in **mR/hr.**

Gamma Rays plus Beta Particle energy = >250 KeV are detected.

Combined Beta/Gamma readings must be reported in units known as Counts Per Minute or CPM.
Standard CD V-700 Meter Face

- The meter was designed to provide linear readings in mR/hr (Probe Closed).
- Bottom of scale is marked in non-linear units C/M known as Counts Per Minute CPM (Probe Open).
- An alternate view of the meter has been provided for a more linear representation of the CPM readings.
CD V-700 Meter View
Converted to read in CPM

- An alternate view of the meter has been developed for:
  - A more linear representation of meter readings in CPM.
  - Help when performing the Operational Check.
  - More accurate Probe Open readings.
CD V-700 Switch Ranges

- **X1 Scale** - 0 - 5 mR/hr. Probe Closed
  - Gamma Exposure Rate
  - OR 0 - 300 CPM Probe Open
  - Gamma plus Beta

- **X10 Scale** - 0 - 5 mR/hr. Probe Closed
  - Gamma Exposure Rate
  - OR 0 - 3,000 CPM Probe Open
  - Gamma plus Beta

- **X100 Scale** - 0 - 50 mR/hr. Probe Closed
  - Gamma Exposure Rate
  - OR 0 - 30,000 CPM Probe Open
  - Gamma plus Beta
CDV-700 Operational Check

1. Turn OFF meter.  
   If you don’t you may get a strong electrical shock.

2. Squeeze and Remove battery retainer clips(s) to install batteries. Check polarity. Replace Clips.

3. Close and Latch the case and attach headphone.

4. Remove the Probe from clip and unwind the probe cable.
5. Turn Selector Switch to X10. **Wait 30 seconds.** Open Beta window.

6. Rub your finger over the foil tape marked “**Operational Check Source**” to locate the position of the source.

7. Place the open probe window directly on the center of this area.

8. **Move probe very slowly.** Find the **highest average reading in CPM.** Compare readings with the range of CPM listed on the calibration label. Readings should agree.
CALIBRATION STATEMENT

CDV-700 VICTOREEN MOD.6A SN:LS25001712

The Massachusetts Emergency Management Agency certifies this instrument has been calibrated on 12/20/01 and is operable when the average reading of the instrument check source is between 1200 - 1800 (CPM) on the X10 Scale with the probe window open.

PA
CD V-700 Checking Background

Once you have completed the Operational Check

Step 7: Try on headphones and check for radiation without reading meter face.

- Listening to headphone is the Best method for determining background and finding radiation.
CD V-700 Operational Check

Determining Background Counts Per Minute (CPM)

1. Set the CDV-700 range selector switch to X1.

2. Open the beta shield.

3. Ensure that a "clicking" sound is heard in headphone.

4. Count the clicks for fifteen (15) seconds.

5. Multiply the total of clicks by four (4) to determine background Counts Per Minute (CPM).
CD V-700 Operational Check

Determining Background Counts Per Minute (CPM)

*for example*

If total counts in fifteen seconds equal 8
\[ 8 \times 4 = 32 \text{ Counts Per Minute (CPM)} \]

Background is “32” Counts Per Minute (CPM)

Record the background CPM obtained on your “Monitor Guide” Form 406 Rev. 7. Re-check background every 30 minutes to eliminate errors due to contamination of the probe or monitoring area.
Form 406 Rev.7 for Standard CD V-700

- Provides specific instructions on how to monitor using V-700.
- Provides procedure to monitor for thyroid uptake, if suspected.
- Use this form to record background levels prior to monitoring.
- Log background in CPM here >
CD V-700 Instrument Use
Performing Area Surveys

➢ Probe may remain in handle clip and held at waist height.

➢ If holding probe in hand orient probe parallel to the surface. **Do not dangle probe by cord!**

➢ **Always cover probe with a plastic baggie to prevent contamination of the probe.**

➢ In areas of unknown radiation, use high- and low-range instruments in tandem.
Begin on the **X1** range. If radiation goes full scale, switch to the **X10** range. If it rises again, switch to the **X100** range.

- Multiplying the meter readings by the range setting =

- **Gamma Exposure Rates in “mR/hr”** (Probe Closed) OR
- **Gamma plus Beta Count Rates “CPM”** (Probe Open).

If the needle peaks, earphone squeals, and needle drops, the meter has probably been saturated (above 1-2 R/hr).

- **Check your High Range (CD V-715) Meter immediately!**
\[ 0.15 \times 1 = 0.15 \text{ mR/hr (Probe Closed)} \]

or

\[ 100 \times 1 = 100 \text{ CPM (Probe Open)} \]
**CD V-700 Practice Meter Readings**

\[ 0.5 \times 10 = 5 \text{ mR/hr (Probe Closed)} \]

or

\[ 300 \times 10 = 3,000 \text{ CPM (Probe Open)} \]
.34 × 100 = 34 mR/hr (Probe Closed)
or
200 × 100 = 20,000 CPM (Probe Open)
Performing surveys of Personnel, Equipment or Vehicles

1. Ensure Headphone is connected.
2. Switch to the X1 Scale.
3. Open probe window.
4. Be sure to cover probe with plastic baggie.
5. Re-check background.
6. Keep probe 1 inch above surface.
7. Survey - move probe slowly at about 1 inch / second.
8. Listen in headphone for increase in clicks or counts.
9. Suspect contamination if levels are 100 CPM or higher above background.
CD V-700 Limitations

- Cannot perform operational check in a radiation field.
- Measures up to only 50 mR/hr or 30,000 CPM.
- May become saturated in higher field of radiation and act erratically.
- Will not respond to all radioactive materials commonly transported. Refer to FEMA’s Good, Some, None Tables. (see forms pack).
CD V-700 Care

✓ Perform regular operational checks.

✓ Log results on your Quarterly Operational Check Form (Refer to Forms Pack).

✓ Turn meter off and remove the batteries (for storage). *Batteries will Leak!!*

✓ Place end of GM tube with wire over center of meter (for storage). Prevents wire breakage.
CD V-700 Equipped With Pancake Probe Detector

- Plug-in Modification for the CD V-700 for enhanced Contamination Monitoring.
- Detects * Alpha, Beta, Gamma and X-ray Contamination.
- Can also be used for area monitoring.
- Introduced to states by FEMA after development of the FEMA Good, Some None Table.
- Two suppliers – S.E. Intl. and Canberra Aptec/NRC.
CD V-700 RP Switch Ranges

- **X1 Scale** - 0 - 300 CPM
  Alpha / Beta / Gamma or X-Ray

- **X10 Scale** - 0 - 3,000 CPM
  Alpha / Beta / Gamma or X-Ray

- **X100 Scale** - 0 - 30,000 CPM
  Alpha / Beta / Gamma or X-Ray
Connecting CD V-700 RP Probe

- Switch must be "Off".
- Unwind cable from stem.
- Remove CD V-700 RP probe from its protective Bubble Wrap Bag.
- Align Pancake Probe Connector Pins with Probe Socket Holes.
- Carefully attach probe to socket. Gently secure by rotating coupling to socket.
CD V-700 RP Operational Check

Specially equipped with Pancake Probe Detector

1. Turn **OFF** meter. *(If you don't you may get a strong electrical shock)*.

2. Remove battery retainer clip to install batteries. Check polarity. Replace Clips.

3. Close case and attach headphone.

Note:
The Lionel Model CD V-700 uses only 2 ea. HD “D” Cell batteries.
4. Turn Range selector Switch to X100 or X10. Check Calibration label for proper scale. Wait 30 seconds.

5. Remove Red Plastic Cap from Probe and place directly on the Operational check source.

6. Take the highest average reading in CPM. Readings should agree with range of CPM values listed on the calibration label.
CD V-700 RP Operational Check

Determining Background in Counts Per Minute (CPM)

1. Set the CDV-700 RP range selector switch to X1.
2. Be sure Red Plastic Cap has been removed.
3. Ensure that a "clicking" sound is heard in headphone.
4. Count the clicks for fifteen (15) seconds.
5. Multiply the total of clicks by four (4) to determine background Counts Per Minute (CPM).
If total counts in fifteen seconds equals 10
10 x 4 = 40 Counts Per Minute (CPM)

Background is “40” Counts Per Minute (CPM)

- Record the background CPM obtained on your “Monitor Guide” Form 406 Rev.8. Re-check every 30 minutes to eliminate errors due to contamination of the probe or monitoring area.
- Background may be slightly higher for the Pancake Detector vs. CD V-700 equipped with standard probe.
Use only with CD V-700 RP Pancake Probe.

Follow monitoring procedure steps 5-9 for this probe.

Can also make general area surveys in CPM.

Log background in CPM here >
Contamination Monitoring with CD V-700 RP (Pancake Probe)

- Readings **must be reported in CPM**.
- Ensure Headphone is connected.
- Switch to the X1 Scale.
- Attach plastic baggie to probe.
- Survey moving probe 1-2 inches per second @ 1” above the surface.
- Consider Person / Vehicle or Object contaminated if readings are 100 CPM or greater above background.
- Probe will only detect Alphas with Plastic Bag removed! Increasing risk of contamination! Be Careful!!
CD V-715 Survey Meter
CD V-715 Characteristics

Range 0 - 500 R/hr

Use
- High level Gamma / X - Radiation related to:
  - WMD Attacks
  - Industrial Accidents
- Backup to CD V-700 when entering unknown radiation environment
CD V-715 Operational Check

Step 1: Turn meter off.

Step 2: Open unit, install battery (observe polarity).

Step 3: Turn selector switch “Zero”; wait two minutes for warm-up.
CD V-715 Operational Check

Step 4: Adjust needle position to "0" on meter face. Zeroing assures accuracy. When zeroing meter, detector does not respond to radiation.

Step 5: Hold selector switch to Circuit Check position to test battery strength, proper installation, and meter circuits. Observe a needle deflection on meter face near or in red area marked Circuit Check.
Step 6: Test operation of each range by rotating selector switch to each position, observing meter deflection.

When not in radiation field, needle should not move further than 0.3 on X100, X10, and X1 scales and 0.6 on the X0.1 scale.
CD V-715 Limitations

- Detects only:
  - Radiation
  - Gamma radiation
CD V-715 Meter Face #1

RANGE = X10

circuit check

R/hr
CD V-715 Meter Face #2

RANGE = X0.1
CD V-715 Meter Face #3

RANGE = X100

circuit check
Three Types of Dosimeters (DRD’s) per Set

- **CDV-730**
  - 0-20 R
  - 2 Per Set

- **CDV-138**
  - 0-200 mR
  - 2 Per Set

- **CDV-742**
  - 0-200 R
  - 6 per Set

Used in the event that high levels of radiation exposure are present.
Direct Reading Dosimeters

DRD’s

- Measure Gamma and X-Radiation.
- Come in varying ranges.
- Provide continuous real-time radiation exposure information.
- Are worn in pairs (200 mR and 20 R) by emergency responders.
- Can be re-used and transferred to other emergency workers.
- Are tested and calibrated annually by MEMA.

CD V- 730 - 20 R
CD V- 138 - 200 mR
Dosimetry Packet Contents

1 Low Range DRD
1 Mid Range DRD
1 TLD
1 Neck Chain
1 Emergency Worker Exposure Form
1 Potassium Iodide (KI) Tablet *

* If advised by MPDH
Direct Reading Dosimetry Indication

SCALE

MILLIROENTGEN

0 50 100 150 200

HAIRLINE
Indicating total external Gamma / X-Ray Exposure

CDV-138
0-200 mR
Low Range DRD
Reading the Direct Reading Dosimeter

Instrument: **Low Range**
Model: **CDV-138**

Scale: **0-200 mR**

Initial Reading: **0 mR**

Final Reading: **50 mR**

Total Dose: **50 mR**
Reading the Direct Reading Dosimeter

Instrument: Mid Range
Model: CDV-730
Scale: 0-20R
Initial Reading: 0 R
Final Reading: 3 R
Total Dose: 3 R
Reading the Direct Reading Dosimeter

Instrument: ____________

Scale: ____________

Initial Reading: ____________

Final Reading: ______

Total Dose: _______
Reading the Direct Reading Dosimeter

Instrument: __________

Scale: __________

Initial Reading: __________

Final Reading: ________

Total Dose: _________
CD V-750 Dosimeter Charger

- Charging Contact
- Case Fastener
- Cap and Chain
- Dosimeter
- Zero Adjust Knob
- HD “D” Cell
CD V-750 Preparation for Use

Step 1: Install one D cell battery.

- Remove center screw and open unit.
- Observe polarity.
- Insert the Battery.
- Close Case.
- Hand tighten center screw.
CD V-750 Preparation for Use

Step 2: Remove cap, top left corner. Press dosimeter **FIRMLY** onto charging contact.

Step 3: Turn zero knob until dosimeter meter reads “0”.

Step 4: Remove Dosimeter from Charger and check setting. Hold up to a light source – **Not on the charger**.
Reading the Dosimeter Properly

- Remove dosimeter from the charger.
- Hold the dosimeter up to a light source and read with the fiber held perpendicular to the earth’s surface.
- Observe where the fiber has been set.
- The fiber should be set on or slightly above zero.
DRD Limits for Emergency Workers

Initial DRD Limit
175 mR

DRD Reporting Levels

100mR  low range DRD
175mR  low range DRD
Each 1R increase  mid range DRD

Higher limits may be established during the emergency by MDPH.

Higher limits may be set for all emergency workers or for individuals who are performing special missions.
Dosimetry should be placed on your neck chain:

• in the center of the chest
• between the neck and waist
• on the outside layer of clothing

** Wear all dosimetry in the same location
Thermo – Luminescent Dosimeters (TLD’s)
Thermo Luminescent Dosimeters (TLD’s)

- Provides the Permanent Legal Record of an individual's Radiation Exposure.
- Passively and Continuously Measures Beta and Gamma Radiation Exposures.
- Are Very Accurate Typically (10mR – KRem)
- Cannot be read in the field by Emergency Workers. Must be exchanged annually and are sent to a lab for analysis.
- Are identical to the TLD’s used by Emergency Workers in the Pilgrim EPZ.
Every CDV-777 Set Contains:

- 6 ea. Whole Body Wallet TLD’s and 1 ea. Control TLD.
- Plan is to issue 2 ea. TLD’s Per shift x 3 shifts for 24 hour coverage.
- Can issue all 6 TLD’s for larger staffing if emergency warrants.
Landauer Wallet TLD (Front View)

- Donned by Emergency Workers along with DRD’s.
- Must Clip to TLD and place on neck chain.
- Once issued - Are not transferable to other emergency workers.
- Must be returned to MEMA for annual exchange.

Anneal or Start Date

TLD Serial Number
Landauer Wallet TLD (Rear View)

**Assignment Instructions**

**Return To Instructions**

**IMPORTANT INSTRUCTIONS**

Record the serial number of this TLD on your REP form. This card should be worn on the torso at all times.

Return this card at an Emergency Worker Monitoring and Decontamination Station.

Forward this card to:

MASSACHUSETTS DEPT. OF PUBLIC HEALTH
BUREAU OF RADIATION CONTROL
305 South Street / Env Rad Lab
Jamaica Plain, MA 02130

US PATENT NO. 3,652,854
Control TLD’s (1 Issued Per Set)

- Always stored in CDV-777 carton with other TLD’s.
- Should never be issued to personnel.
- Are used to subtract normal background exposure from worker exposures.
- If possible - Control TLD must be kept away from “Hot Zone” to avoid added exposures.
Potassium Iodide (KI)

3 day supply for 6 emergency workers

- KI protects only the Thyroid Gland from the uptake of Radioactive Iodine 131.
- 2 Btls./CDV-777 Set.
- 14 ea. 130 mg Tablets per Bottle.
- Only take if advised by MDPH.
- Read enclosed advisory for possible side effects.

Dose is 1 Tablet / Day for 10 days
Sample
Emergency Worker Exposure Form

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**TLD SERIAL No. 03421**

1. Read Dosimeters every 15 minutes unless otherwise directed.
2. Report the following to your Radiological Officer/Dosimetry Coordinator:
   a. 100 mR on 0-200 mR DRD
   b. 175 mR on 0-200 mR DRD
   c. Each 10 increase on your 0-200 DRD
3. MDPH will establish DRD limits and give permission to exceed them as the accident situation warrants. The initial limit is 175 mR.
4. Notify your Radiological Officer/Dosimetry Coordinator and unless directed otherwise, report to your assigned emergency facility when any of the following occurs:
   a. Completion of assignment
   b. Damaged or lost dosimetry
   c. Loss of communications
   d. Directed by proper authority to leave

**NOTE:** Your assigned facility or the emergency worker monitoring and decontamination station will retain the top two copies of this form, all dosimetry, and any contaminated items.
Instrumentation Exercise # 1
Working in Teams of 2
Using Both Standard and Pancake CDV-700 Meters

1. There are three small sources to measure using both meters.
2. Start on the X1 Scale.
3. Place probe(s) on the surface of the paper(s), record readings CPM or mR/hr on your form.
4. With the standard V-700 take readings with probe open and closed.
5. Take the same series of readings using the CDV-700 with Pancake Detector.

Points to Remember!!

Probe Open readings will be in CPM.
Probe Closed readings will be mR/hr.
Pancake Probe readings are reported in CPM.
Using the Std. CDV-700 Probe Open - X1 approach the package containing RAM's. Note increase in background as you near.

- Identify the Radioactive Labels on package.
- ID RAM contained in this package. What are acceptable radiation levels for this package @ surface and 1 meter?
- Measure radiation levels on contact and @ 1 Meter from the package.
- Should the CDV-700 Probe be Closed or Opened to determine if package is still intact or damaged?
- Take same set of readings using a CD V-700 equipped with a Pancake. How do readings compare with Standard CD V-700?
- There may be a second source nearby. Can you locate it using the Pancake?
Instrumentation Exercise #3
Direct Reading Dosimeters
Reading, Recording and Zeroing Dosimeters

There will be four numbered trays labeled 1 – 4. Each tray will hold one or two dosimeters placed over a light box for you to read.

1. Identify and Record Dosimeter Model - i.e. CDV-138, 730 or 742 and Range (200 mR, 20 R or 200 R).

2. Read each Dosimeter and Record the readings on your form.

3. Practice zeroing dosimeters using the CDV-750 Dosimeter Charger and the FEMA Model 6 Self-Powered Charger.
1. Based on your readings - What kind of RAM's (Alpha, Beta, Gamma) were used for source readings 1, 2 and 3?

2. Were both CDV-700’s capable of detecting these sources?

3. Which of the CDV-700’s do you think is better suited for detecting the presence of unknown types of RAM contamination in the environment.

4. Which of the CDV-700’s is better suited to measuring the degree of Gamma radiation hazard in milliRoentgens/Hr or mR/Hr.
Exercise Review Q&A’s (con’t)

Exercise # 2

1. Which of the two CDV-700’s is the appropriate meter for determining if a package has been labeled properly? Why?

2. What was the maximum surface reading in mR/hr. obtained from the package of RAM?

3. Based on your readings - Do you think this package meets packaging regulations?
Exercise Review Q&A’s (con’t)

Exercise # 3

1. What Dosimeter Model(s) were placed in trays # 1, 2, 3, 4?

2. What was the range or scale of these dosimeters?

3. What did these dosimeters read?
Annual Instrument Service

Contact the MEMA RIM&C Facility for repairs, annual instrument calibration, exchange of TLD’s and KI at:

Massachusetts Emergency Management Agency
Maintenance & Calibration Facility
87 Barnum Rd., Bldg. T-3710 (MANG)
Devens, MA 01432-3524

Tel: 978-772-3122  Fax: 978-772-4111  email: pares123@aol.com