SAND2007-5111P

Radiation Instrumentation & Monitoring

CMC
COOPERATIVE MONITORING CENTER

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

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Radiation Instrumentation & Monitoring

- Categories of Radiological Survey Instruments
- Proper Application and Limitation of Contamination Survey Instruments
- Proper Application and Limitation of Radiation Exposure Survey Instruments
- Commonly Used Dosimetry Devices
- Air Sampling Equipment

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Introduction

- **Radiation can *not* be detected by our senses**
- **Survey instruments *can*:**
  - **Easily and accurately measure radiation and contamination**
  - **Help evaluate radiological hazards**

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Radiological Surveys

- Two categories of instruments available
  - Those that measure – report- radiation
  - Those that measure – report- contamination
- Some survey instruments are designed to do both

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Basic Theory

- Ionizing radiation interacts with detector material and produces a reading (on display, meter)
- In some instruments, the detector is connected to the meter by a cable
- In other instruments, the detector and meter are housed in one unit

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Contamination Survey Instruments

- Typically display in counts per minute (CPM)
- Very sensitive
- Detects alpha, beta, & gamma radiation
- Window is very fragile
- *Not* designed for measuring radiation exposure

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Application of Contamination Survey Instruments

- Locating contamination on personnel and equipment
- Determining the effectiveness of decontamination
- Verifying contamination control boundaries
- Determining the extent and magnitude of a contaminated area

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Application of Contamination Survey Instruments

- Follow procedures for pre-operational check of the instrument
  - Physical damage
  - Calibration
  - Battery condition
  - HV (if applicable)
  - Source response check
- Verify the instrument is on and set to the lowest (most sensitive) scale
- Check for audio and visual response

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Application of Contamination Survey Instruments

- Verify the background radiation level
- Hold the probe ½ inch (1 cm) from surface
- Move the probe slowly, 1 – 2 inches (2.5 – 5 cm) per second
- Pause if the count rate increases
- Use same procedure for people, surfaces, or packages

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ASP-1 with HP-260 GM Detector

Example:

Alpha, Beta, Gamma Contamination Monitor

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ASP-1 with AC-3 Alpha Scintillation Detector

Example:

Alpha Contamination Monitor

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Reading the Meter Face

- Analog instruments can be more difficult to read than newer digital instruments
- Often require the user to multiply the displayed reading by a multiplier, based upon which scale the instrument is set to

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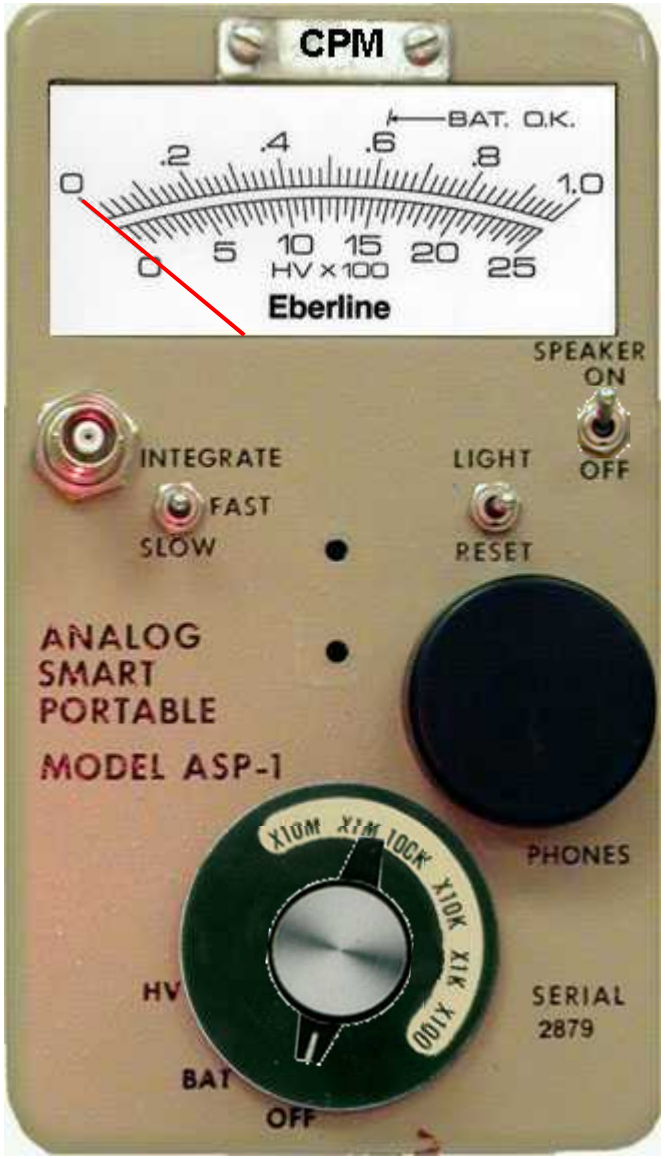
Operator Adjustable Controls

- Battery check
- HV
- Range/Scale Selector
- Fast/Slow response
- Speaker



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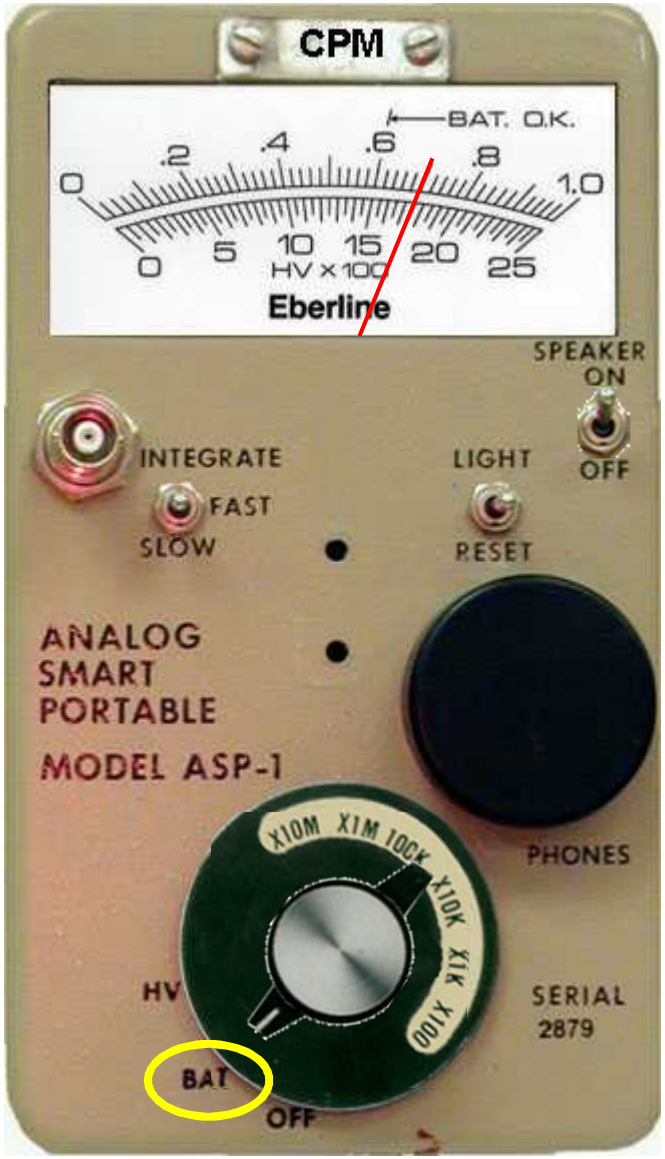
Reading the Meter

Scale = BAT

Meter = 0.7

Reading = BAT. O.K.



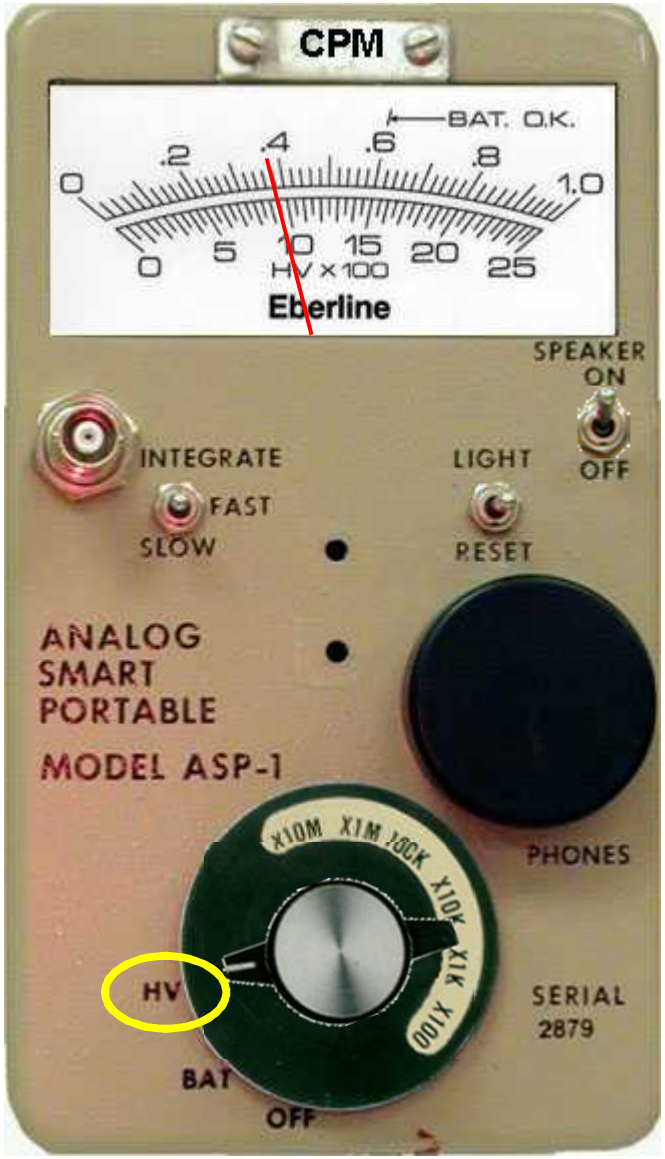
Operator Adjustable Controls

Scale = HV

Meter = 9.5

Reading = 950

(read bottom scale HV X 100)



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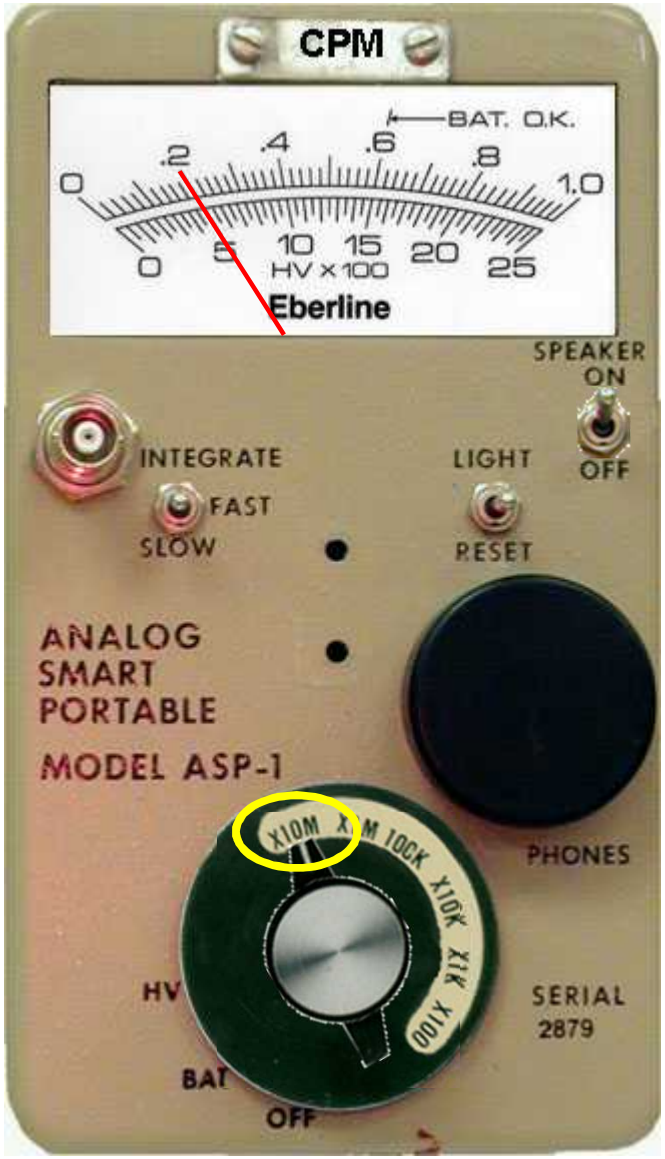
Reading the Meter

Scale = X10M

Meter = 0.2

Reading = 2000000 CPM



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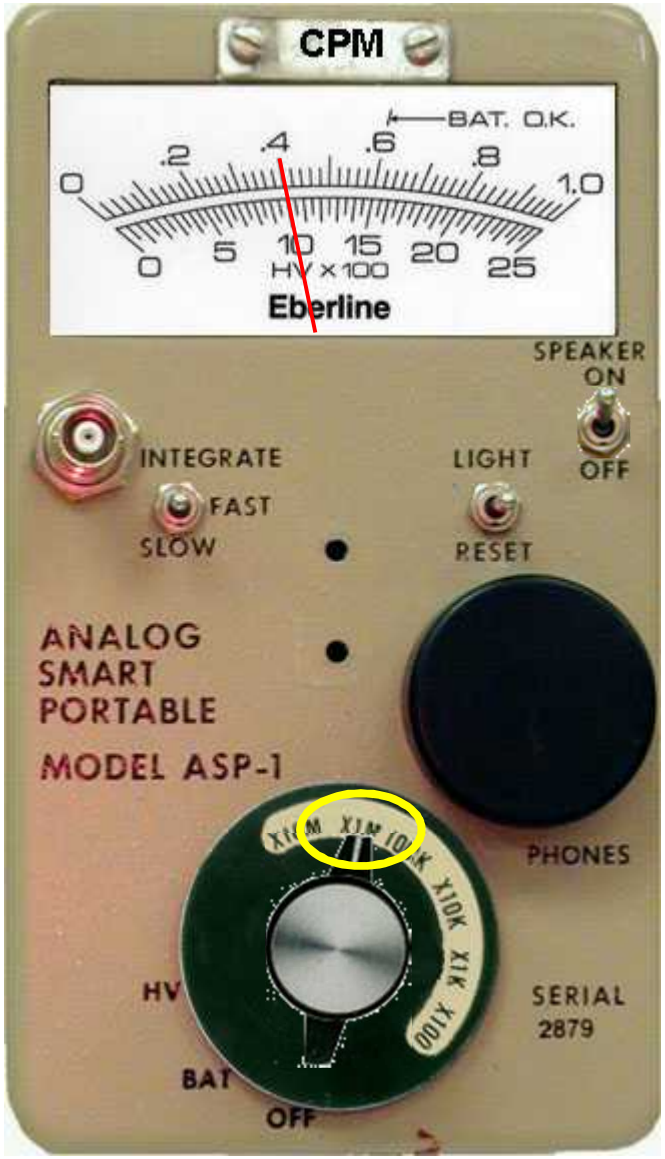
Reading the Meter

Scale = X1M

Meter = 0.4

Reading = 400000 CPM



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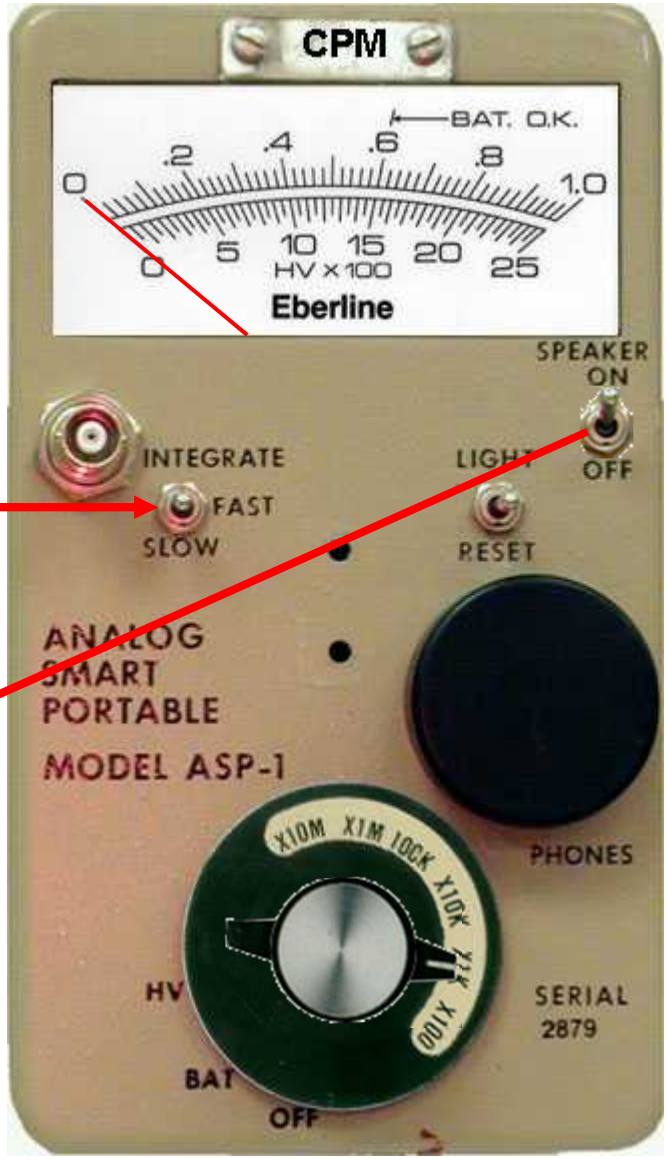
Reading the Meter

- Fast/Slow response
- Speaker



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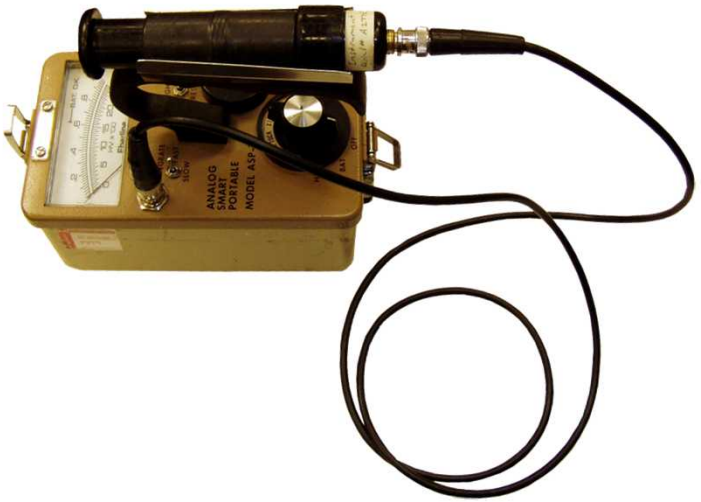
Radiation Exposure Survey Instruments

Typically read in:

- **milliRoentgen/hour (mR/h)**
- **Roentgen/hour (R/h)**
- **microSievert (μSv/h)**
- **milliSievert/hour (mSv/h)**
- **Sievert/hour (Sv/h)**



Best suited for use when entering a field of radiation

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Application of Radiation Exposure Survey Instruments

- Establishing control zone boundaries
- Controlling personnel exposure
- Assessing package integrity
- Locating sources of radiation
- Locating “streaming” of radiation

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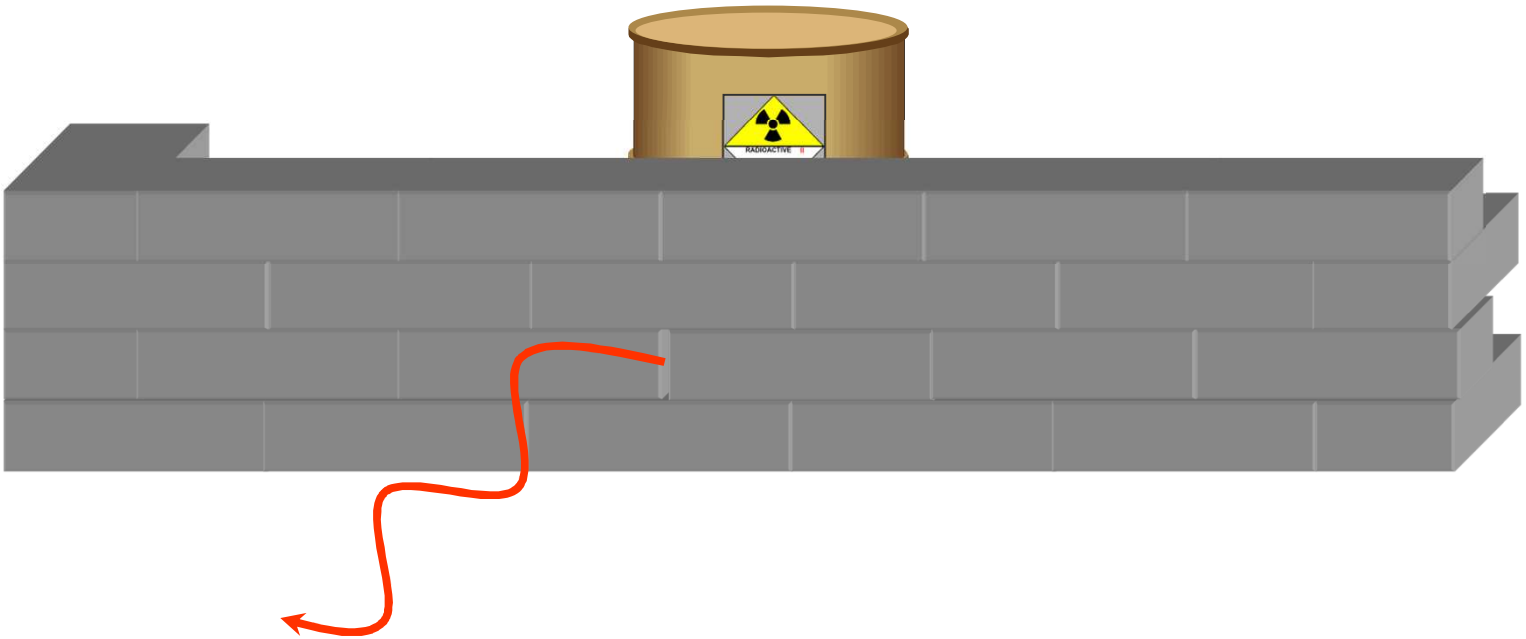
Application of Radiation Exposure Survey Instruments

Streaming



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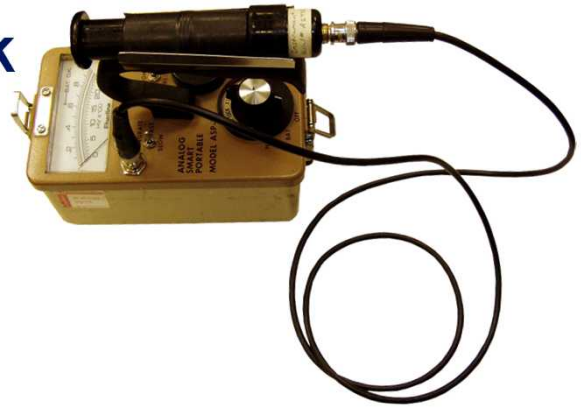
Application of Radiation Exposure Survey Instruments

- Start with low-range survey instrument
- Follow procedures for pre-operational check of the instrument
  - Physical damage
  - Calibration
  - Battery condition
  - HV (if applicable)
  - Source response check



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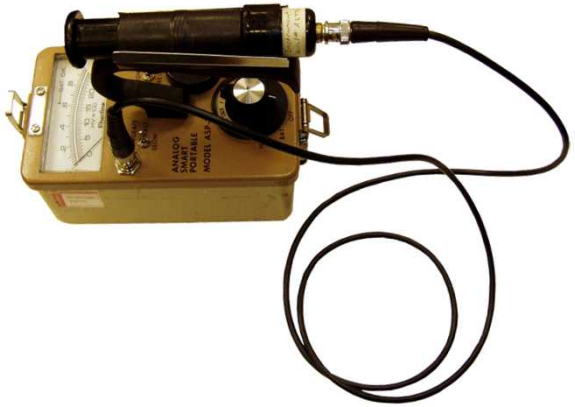
Application of Radiation Exposure Survey Instruments

- Verify the instrument is on and set to the highest scale – ***why?***
- Check for audio and visual responses
  - Adjust scale to a lower setting as needed



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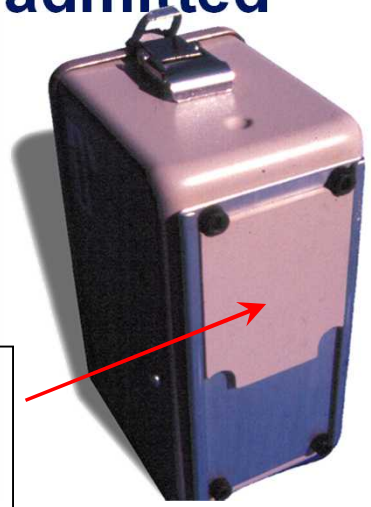
Application of Radiation Exposure Survey Instruments

- Many instruments employ a movable beta shield to differentiate beta and gamma radiation
- With shield open, beta and gamma admitted - measured
- With shield closed, gamma only admitted
- Open window reading minus closed window reading = beta contribution



Movable beta shield

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Application of Radiation Exposure Survey Instruments

- Many survey instruments have meter faces that read in both CPM and mR/hr
- When using a side window GM probe, readings should be recorded in mR/hr when the probe window is closed, and in CPM when the probe window is open – *why?*

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Application of Radiation Exposure Survey Instruments

- Start with the instrument set to the highest scale
- Monitor with the detector in front of you at waist level
- Periodically monitor above and below this level and in a 360º circle to ensure that you have not walked by a source of radiation

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Eberline ASP-1 with HP-270

Example:

Beta / Gamma Counter;
Compensated Gamma
Exposure Meter

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Eberline RO-20

Example:

Exposure Rate meter

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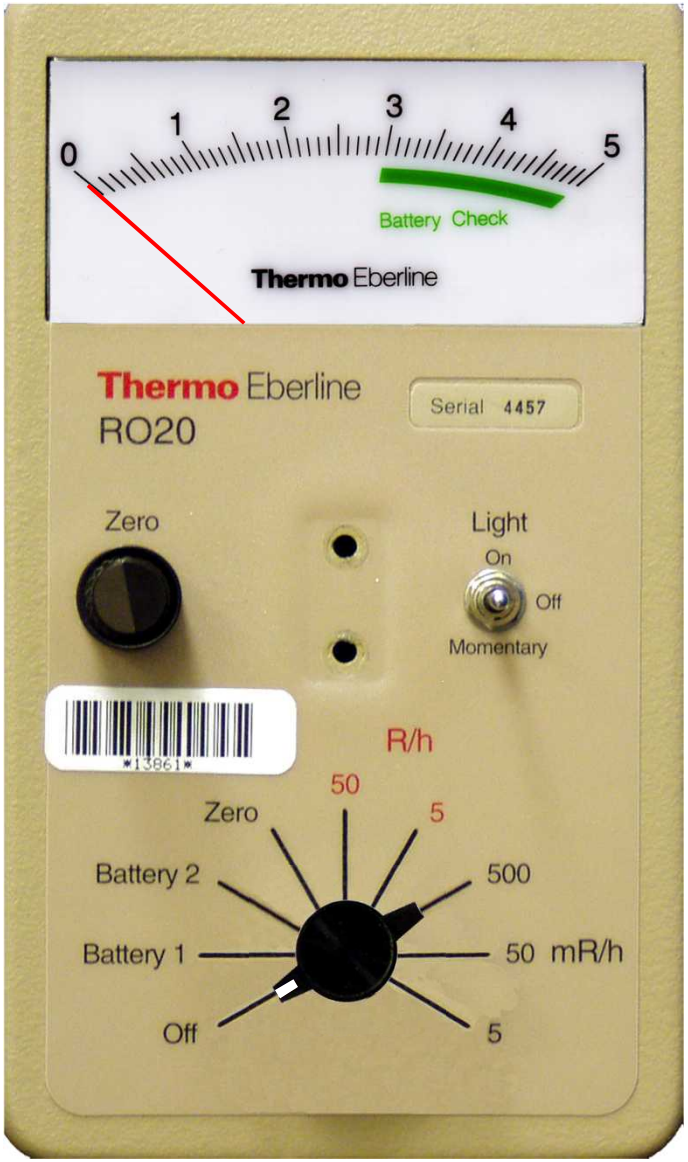
Operator Adjustable Controls

Example: Exposure Rate Meter
Gamma Dose

- **Off**
- **Battery 1 & 2**
- **Zero**
- **Range/Scale Selector**
  - **50 R/h (500 mGy/h)**
  - **5 R/h (50 mGy/h)**
  - **500 mR/h (5 mGy/h)**
  - **50 mR/h (0.5 mGy/h)**
  - **5 mR/h (50 µGy/h)**
- **Light**



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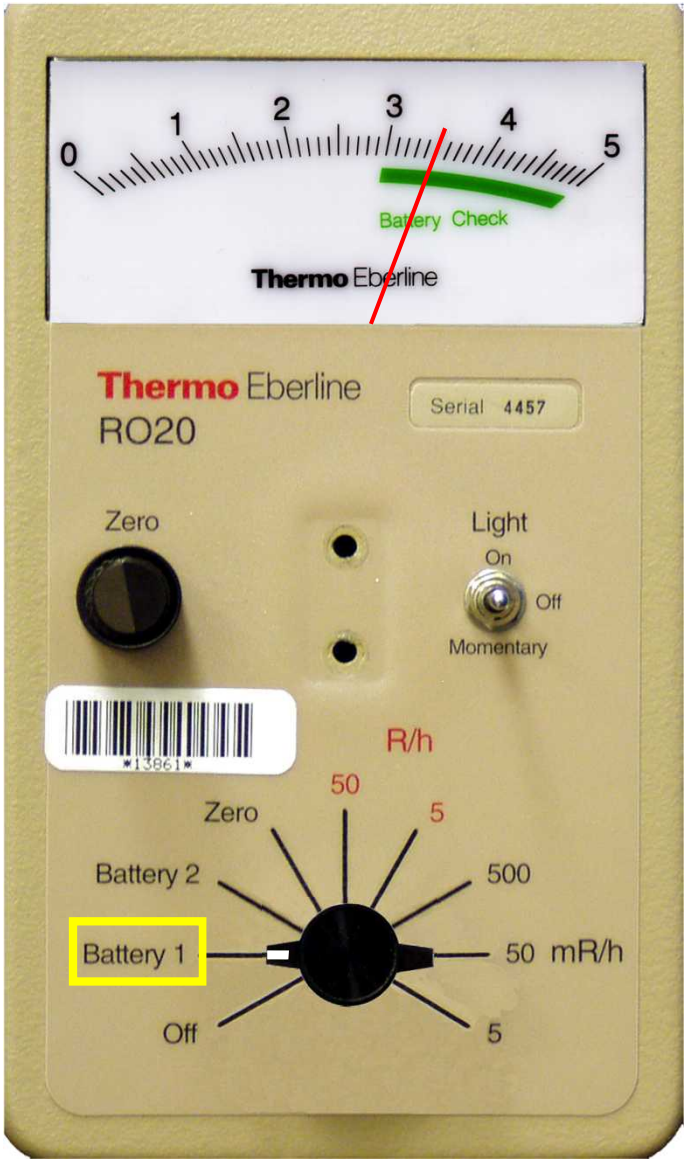
Operator Adjustable Controls

Range = Battery 1

Meter face = 3 – 5

Reading = Battery Check



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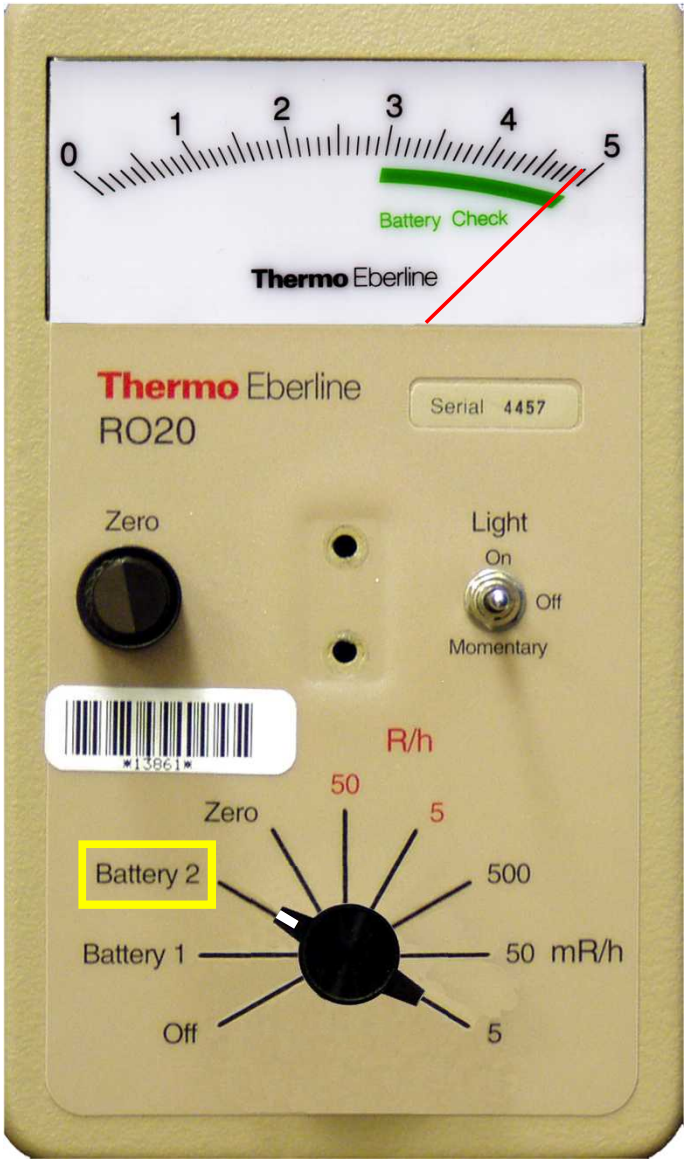
Operator Adjustable Controls

Range = Battery 2

Meter face = 3 – 5

Reading = Battery Check



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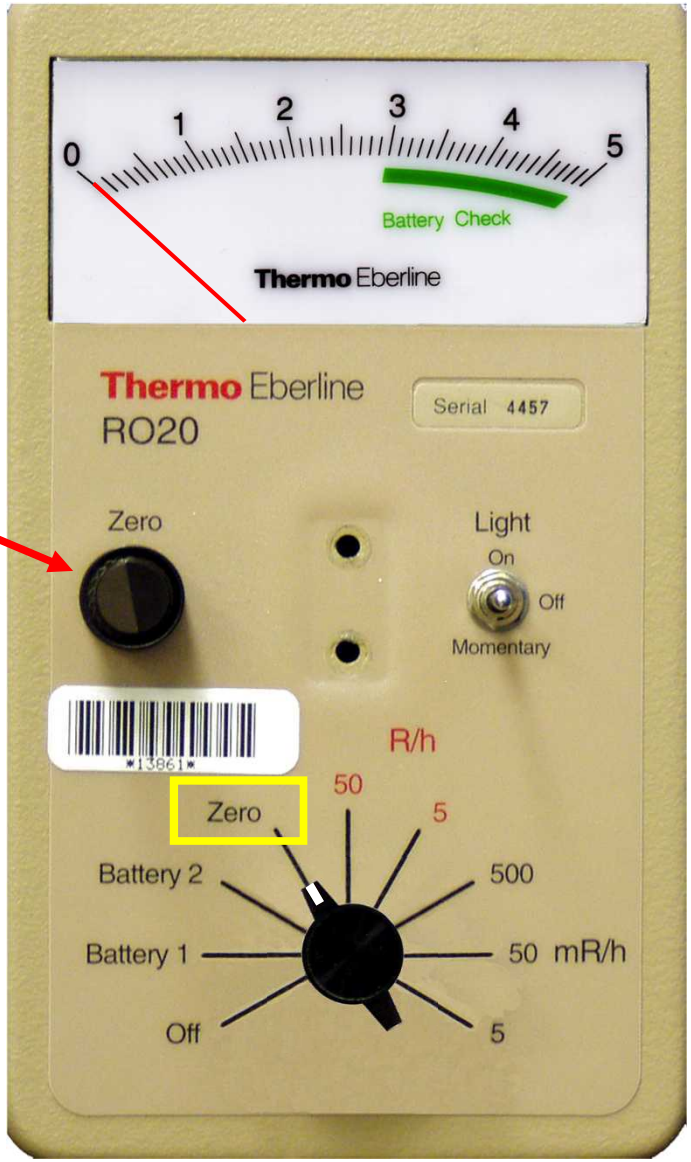
Operator Adjustable Controls

Range = Zero

Meter face = 0

(adjust as necessary in a low radiation field)

Reading = 0



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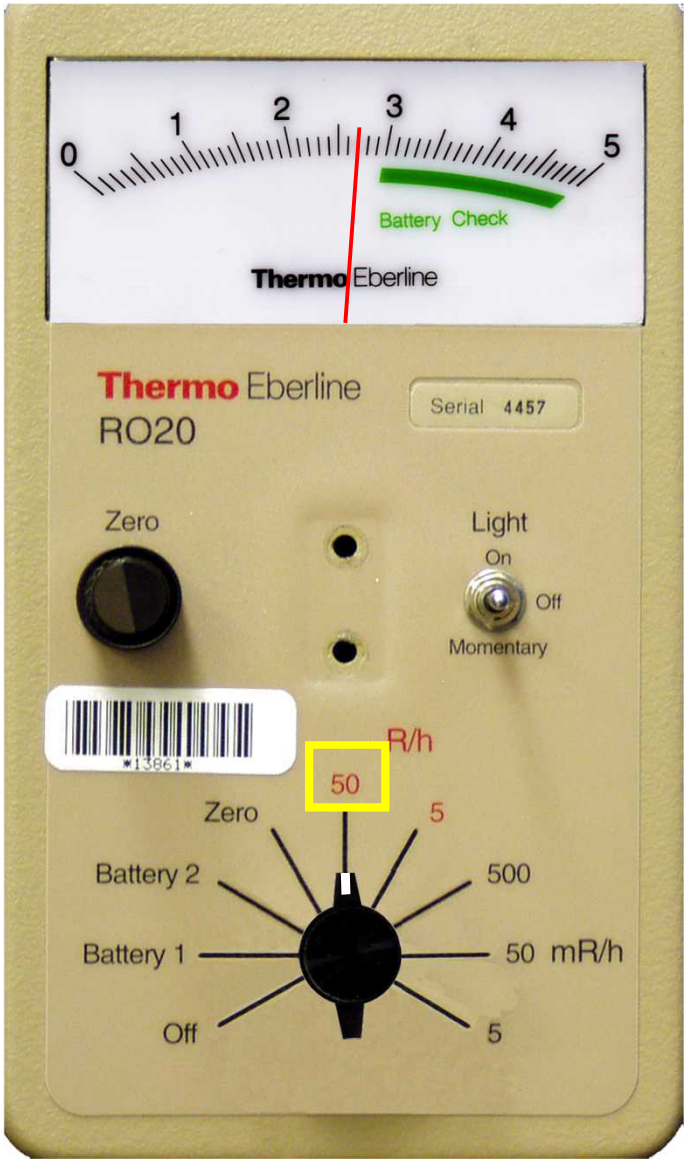
Operator Adjustable Controls

Range = 50 R/h

Meter face = 2.7

Reading = 27 R/h



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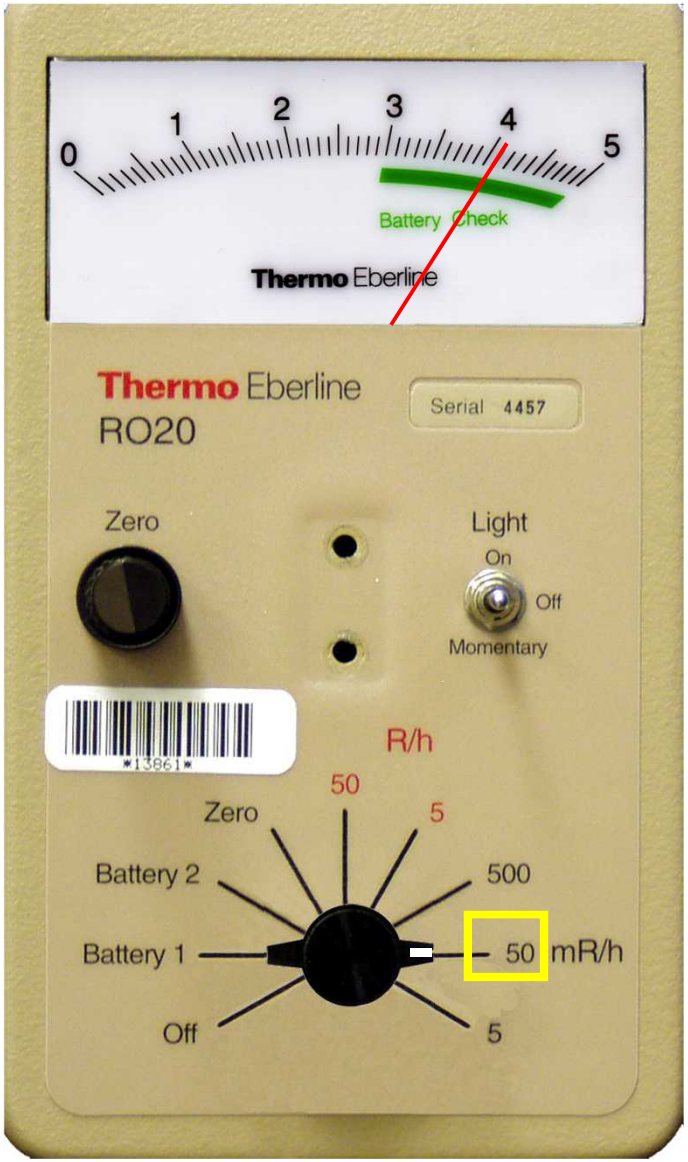
Operator Adjustable Controls

Range = 50 mR/h

Meter face = 4.1

Reading = 41 mR/h



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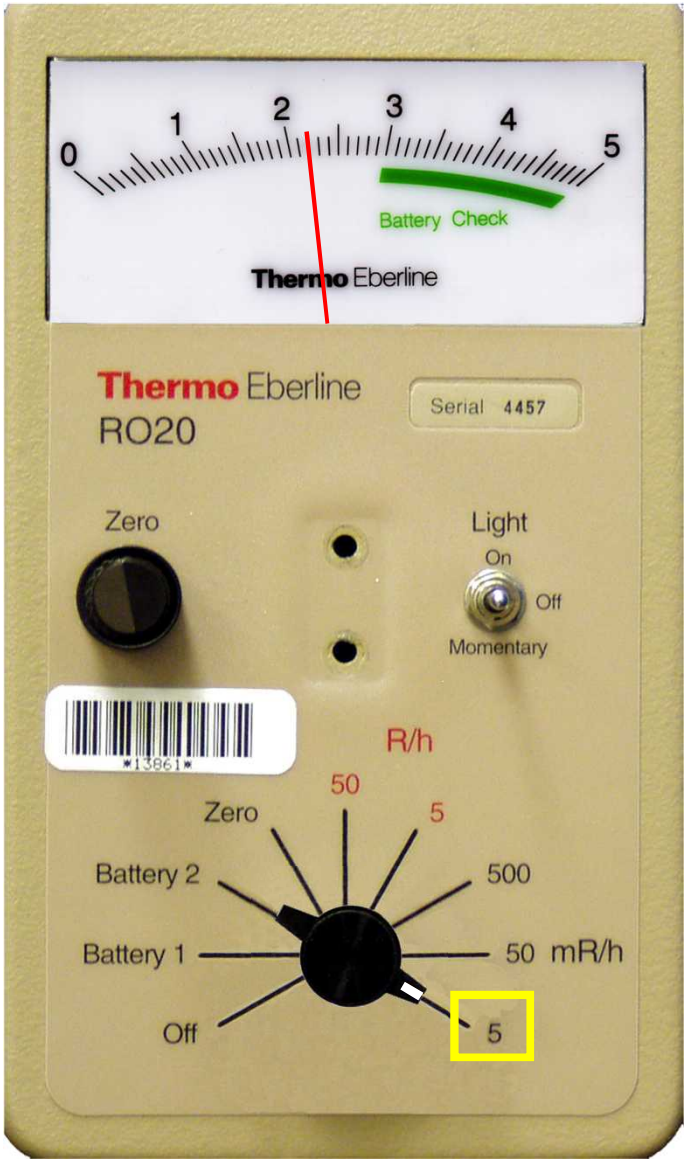
Operator Adjustable Controls

Range = 5 mR/h

Meter face = 2.2

Reading = 2.2 mR/h



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Bicron Micro Rem

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Operator Adjustable Controls

- off
- bat.
- HV
- Range/Scale selector
  - x 1000
  - x 100
  - x 10
  - x 1
  - x 0.1

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Reading the Meter

Scale = bat.

Meter = 130 – 200

Reading = bat. ok

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Reading the Meter

Scale = HV (High Voltage)

Meter = 115 - 125

Reading = HV ok

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Reading the Meter

Scale = x 1000

Meter = 20

Reading = 20000 µRem/h

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Reading the Meter

Scale = x 10

Meter = 120

Reading = 1200 µRem/h

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Instrument Readings

Scale = x 0.1

Meter = 180

Reading = 18 µRem/h

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Canberra InSpector 1000

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In-Situ Gamma Spectroscopy

- Digital hand-held Multichannel Analyzer
- Internal G-M tube
  - High dose/count rate measurements
- Available probes
  - 1.5” × 1.5” NaI(Tl)
  - 2” × 2” NaI(Tl)
  - 2” × 2” Stabilized NaI(Tl)
  - 3” × 3” NaI(Tl)
  - LaBr probe - 1.5” × 1.5” Stabilized
- Optional neutron probe

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In-Situ Gamma Spectroscopy

- Approximately 12 hours operation (fully charge
- 50 keV – 3 MeV energy range
- Alarming setpoints for dose, dose rate, and specific nuclide
- Multiple nuclide libraries and analysis options
- Multiple efficiency calibrations for both measured and calculated

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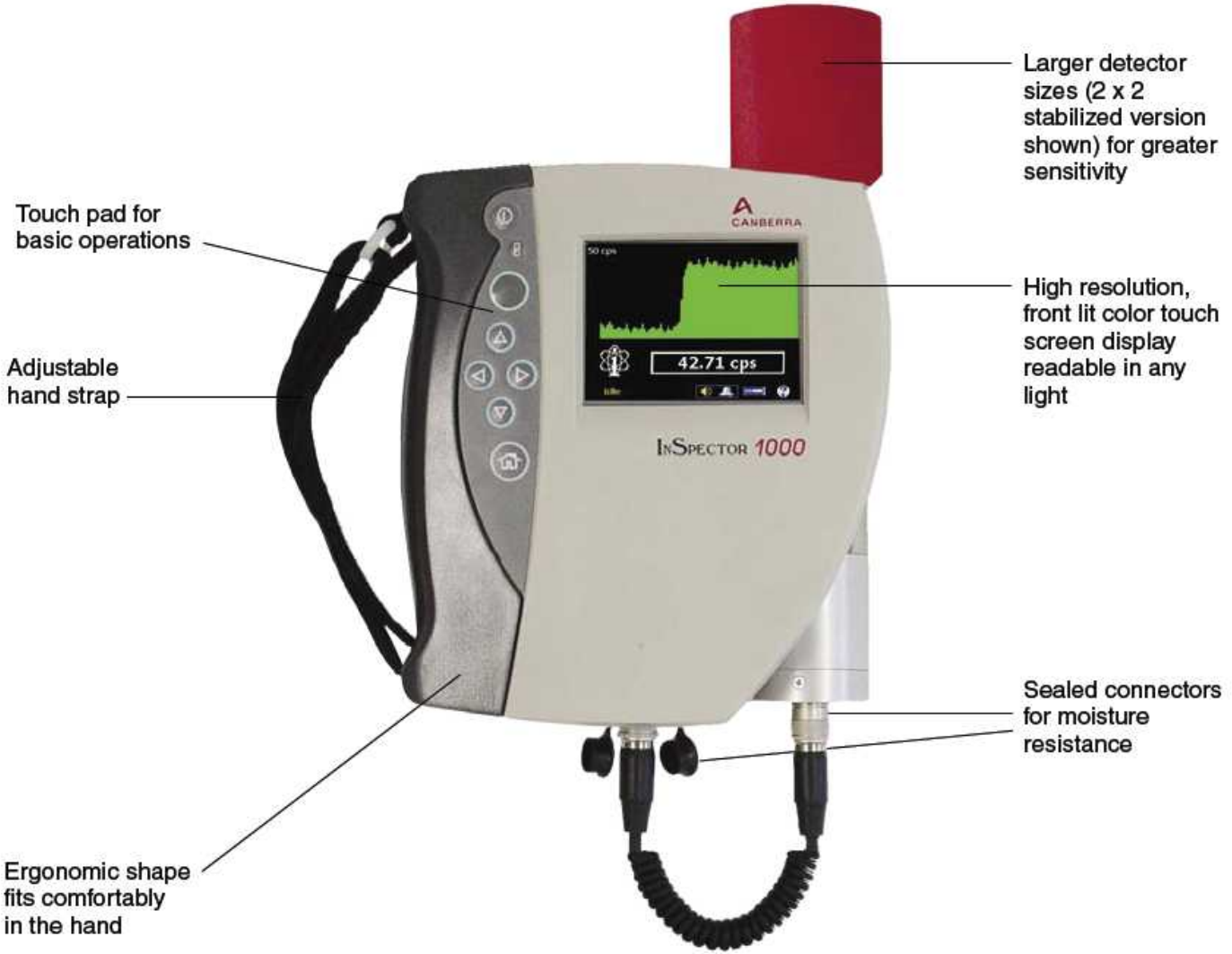
In-Situ Gamma Spectroscopy



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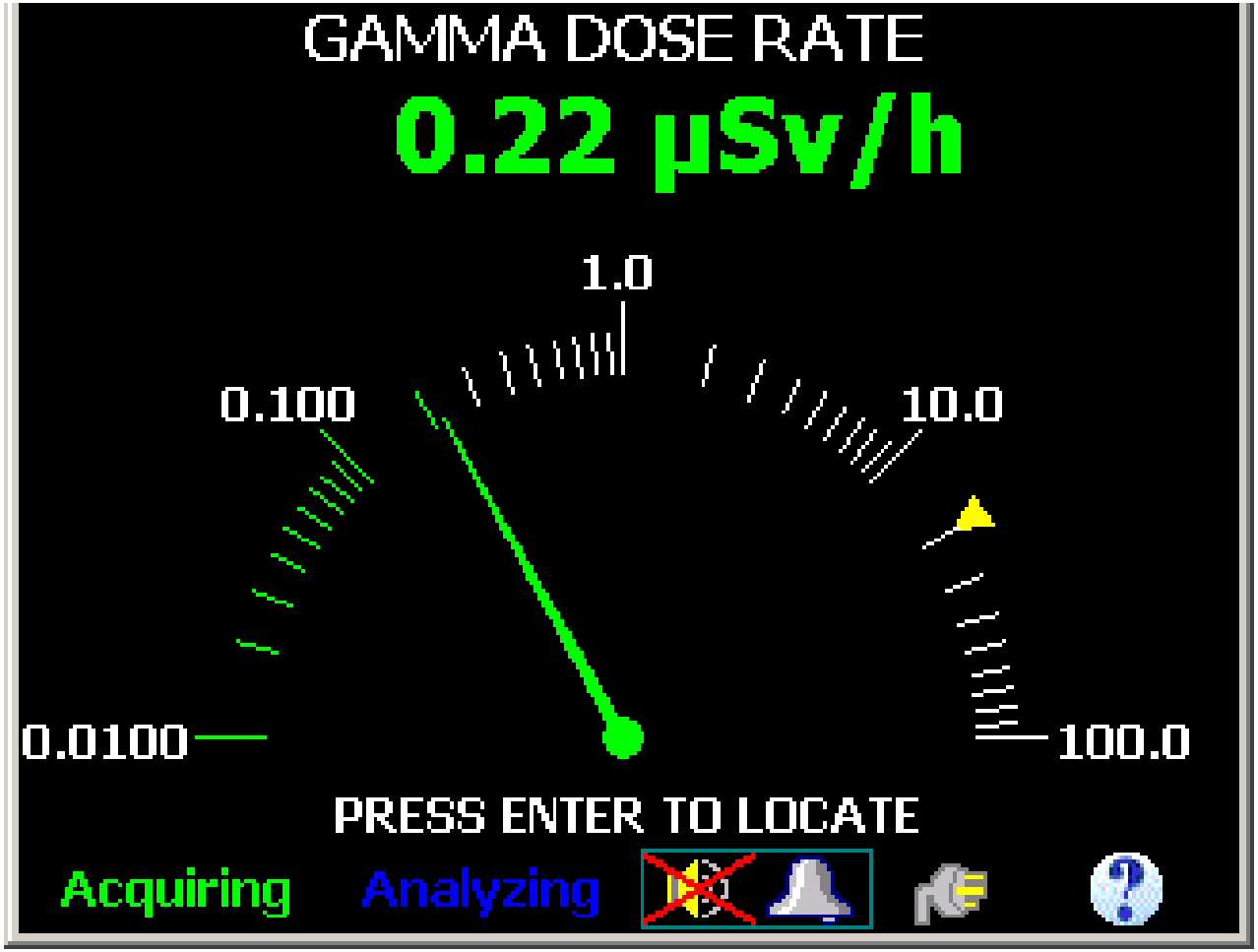
In-Situ Gamma Spectroscopy

Monitor Dose Rates in Area



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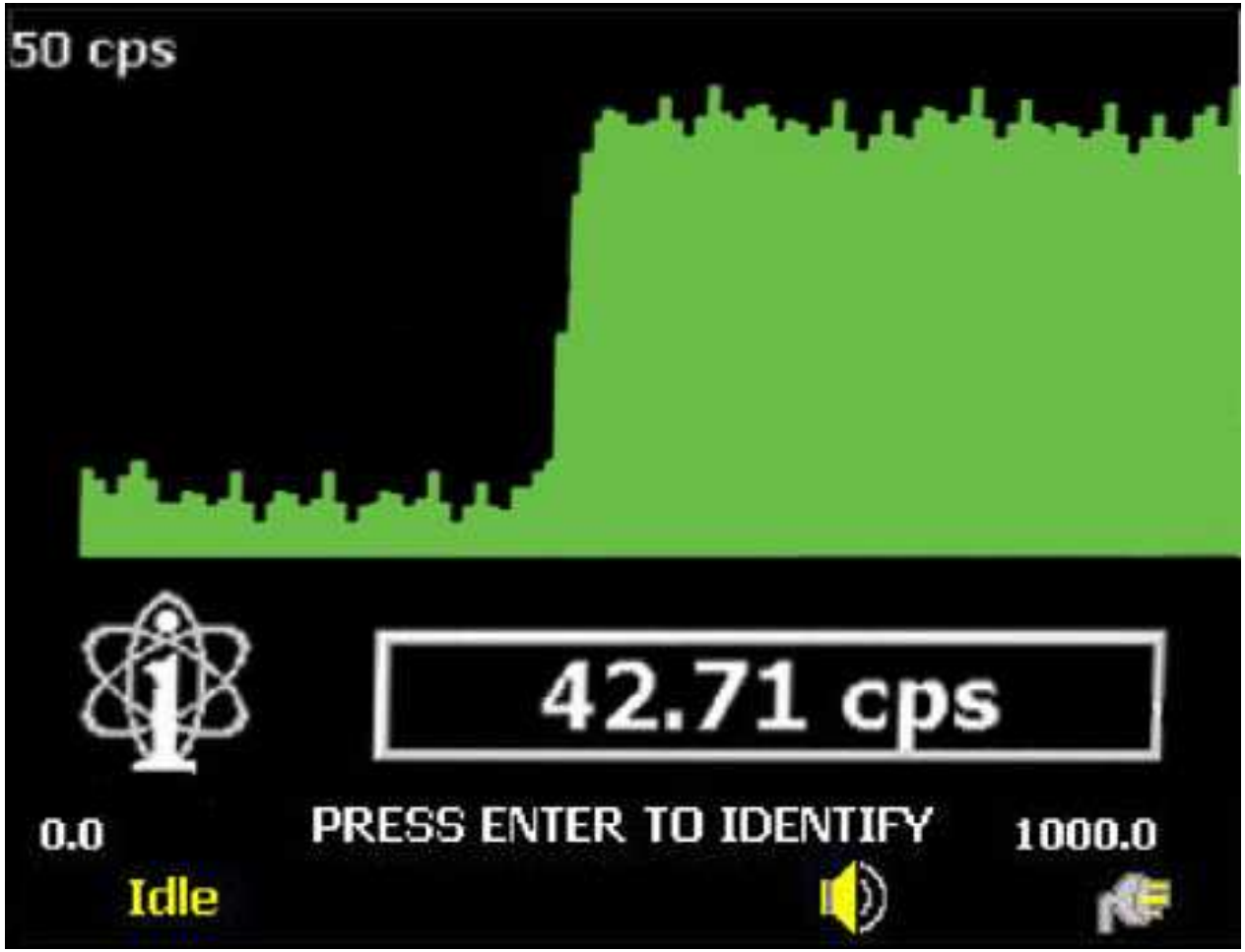
In-Situ Gamma Spectroscopy

Locate the Source



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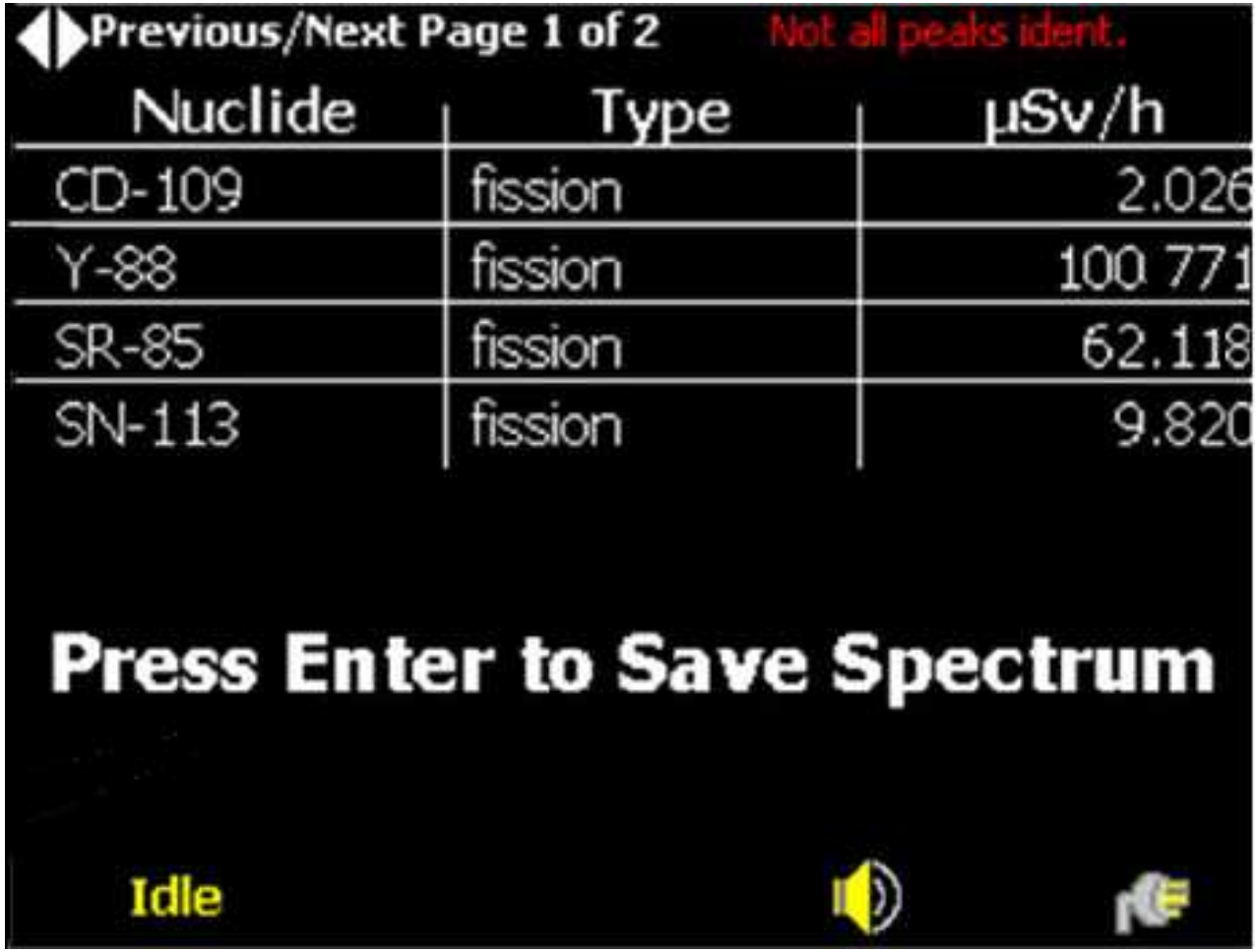
In-Situ Gamma Spectroscopy

Identify & Quantify Source



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In-Situ Gamma Spectroscopy

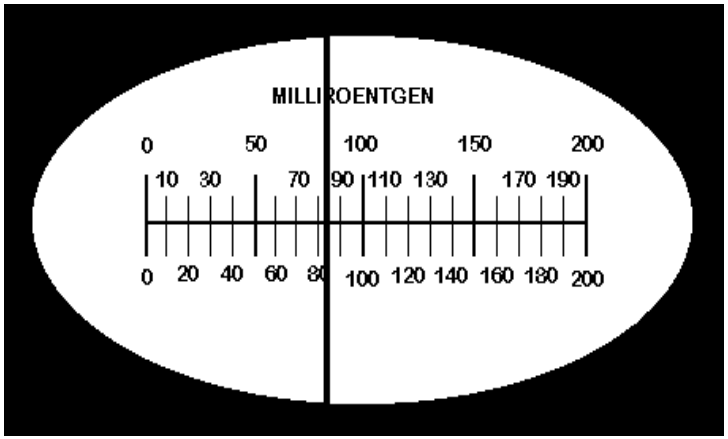
Default Libraries

- **Nal-Norm – normal radioactive materials found in nature**
  - **K-40,Ra-226,Th-232,U-235,U-238**
- **Nal-Med – common medical isotopes**
  - **Ga-67,Tc-99m,Pd-103,In-111,I-123.I-125,I-131,Xe-133,Ir-192,Tl-201**
- **Na-SNM – special nuclear material**
  - **U-233,U-235,U-238,Pu-239**
- **Nal-Indu – common industrial isotopes**
  - **Na-22,Co-57,Co-60,Ba-133,Cs-137,Eu-152,Ir-192,Ra-226,Th-232,Am-241**

Dosimetry Devices

Self-Reading Dosimeter (SRD)

- Measures accumulated dose
- Hold up to light and look through the eyepiece to read
- Check frequently while in area



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Dosimetry Devices

Electronic Dosimeter (ED):

- **Measures accumulated dose**
- **Utilizes digital readout**
- **Many options available**
- **Audible response - chirp rate varies with radiation dose rate**

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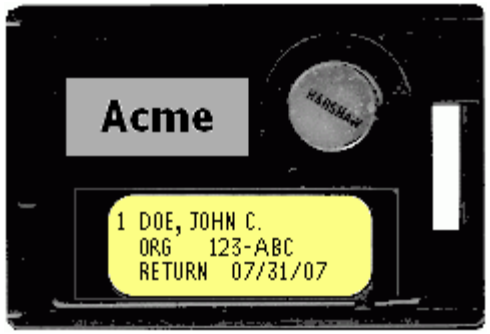
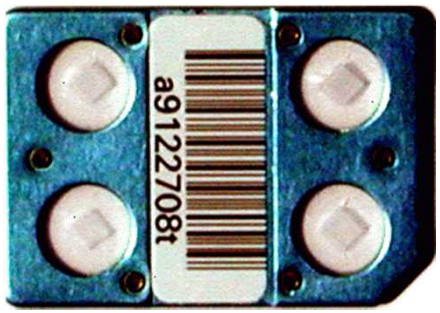
Dosimetry Devices

Thermoluminescent Dosimeter (TLD):

- Measures accumulated dose
- Does *not* provide on-the-spot indication of dose
- Specialized equipment required to "read" TLD
- Worn by specialized hazmat teams





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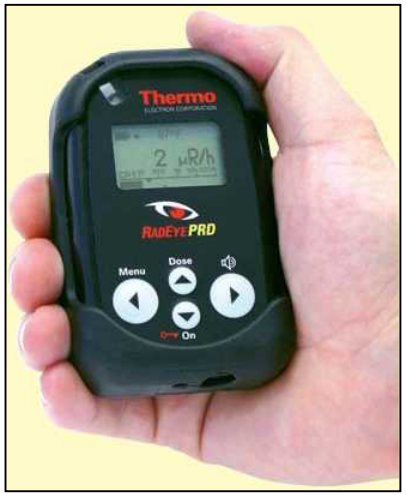
Electronic Pager

RadEye PRD

- 60 keV – 1.3 MeV
- 0.01 µSv/h – 250 µSv/h
  (1 µR/h – 25 mR/h)
- Dose and dose rate alarms
- 6 cc NaI(Tl) detector
- Data downloadable to PC



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Air Sampling Equipment

Air sampling equipment is used to collect radioactive material that has been dispersed in the air

- Qualitative field counting is possible but may result in erroneous decisions due to:
  - Radon interference
  - High background radiation levels
- Sampling media is sent to a laboratory to determine the type(s) and amount of radioactive material

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Air Sampling Equipment

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