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MODIFICATION RECORD

Change Number	Affected Pages	Description of Change	Management Approval
01	Various	Changed terms to reflect the new 835 changes.	10-7-08

Course Title: **Radiological Control Technician**
Module Title: **Contamination Monitoring Instrumentation**
Module Number: **2.17**

Objectives:

2.17.01 List the factors which affects an RCT's selection of a portable contamination monitoring instrument.

☞ 2.17.02 Describe the following features and specifications for commonly used count rate meter probes used at your site for beta/gamma and/or alpha surveys:
a. Detector type
b. Detector shielding and window
c. Types of radiation detected/measured
d. Energy response for measured radiation
e. Specific limitations/characteristics.

☞ 2.17.03 Describe the following features and specifications for commonly used count rate instruments used at your site.
a. Types of detectors available for use
b. Operator-adjustable controls
c. Specific limitations/characteristics.

☞ 2.17.04 Describe the following features and specifications for commonly used personnel contamination monitors at your site.
a. Detector type
b. Detector shielding and housing
c. Types of radiation detected/measured
d. Specific procedures for source checks
e. Specific procedures for sample counts.

☞ 2.17.05 Describe the following features and specifications for commonly used contamination monitors used at your site (tool, bag, laundry monitors).
a. Detector type
b. Detector shielding and window
c. Types of radiation detected/measured
d. Energy response for measured radioactivity
e. Specific limitations/characteristics.

References:

1. 10 CFR Part 835 Occupational Radiation Protection
2. DOE-STD-1098-99 U.S. Department of Energy Radiological Control Standard
3. ANSI N323A-1997, American National Standard Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments
4. "Basic Radiation Protection Technology"; Gollnick, Daniel; Pacific Radiation Corporation, Altadena;4th Edition, January 2000
5. Knoll, Glenn F., "Radiation Detection and Measurement," 3rd Edition, John Wiley & Sons, New York, 2000
6. ANL-88-26 (1988) "Operational Health Physics Training," Moe, Harold; Argonne National Laboratory, Chicago
7. Product Technical Manuals for instruments discussed
8. TPR-7325 “Portable Health Physics Instrumentation Functional and Performance Checks”
9. TPR-6872, “NE Technology SHM4A Hand Monitor
10. Form 441.70 - “Instrument Return Tag”

INTRODUCTION

This lesson covers contamination monitoring instruments commonly used by the RCT in the performance of their duties at the various facilities throughout ICP. The RCT uses information from these monitoring instruments to identify and assess the hazards presented by contamination and establish protective requirements for work performed in contaminated areas.

Measurements using portable contamination monitoring (count rate) instruments provide the basis for assignment of practical contamination and internal exposure controls. To establish the proper controls, the contamination measurements must be an accurate representation of the actual conditions. Measurements use non-portable contamination monitors such as an Eberline PCM-1B or PM-6, are used to identify personnel contamination prior to exiting controlled areas or facilities. Measurements using counter - scalers to determine the levels of transferable contamination on specific location samples are the basis for contamination postings and material releases from controlled areas.

Many factors can affect how well the measurement reflects the actual conditions, such as:

- Selection of the appropriate instrument based on the type of contamination, the specific energy of the radiation emitted, dimensions, and location of the contamination field, and other factors.
- Correct operation of the instrument based on the instrument operating characteristics and limitations.
- Calibration of the instrument to a known radiation source similar in type, energy and intensity to the radioactive contamination likely to be measured.
- Other radiological and non-radiological factors that affect the instrument response, such as RF fields, radioactive gases, high background radiation, humidity, and temperature.

2.17.01	List the factors which affects an RCT's selection of a portable contamination monitoring instrument.

The selection of the proper instrument is critical to ensure the data obtained is accurate and appropriate. Instrument selection is based on the characteristics and specifications for that - instrument as compared to the required measurements.

Several factors should be considered when selecting the instrument.

- The type of radiation to be measured. For instance, the Ludlum Model 177 with a Ludlum Model 43-92 Alpha Scintillator Probe is suitable for alphas. The Ludlum Model 177 with a Ludlum Model 44-9 pancake hand probe is suitable for most betas. There are a very small number of radionuclide’s that emit a gamma only

(e.g. Be-7 and Sr-85) that require special care. Neutrons are not monitored during contamination surveys.

- The energy of the radiation to be measured. The Ludlum Model 44-9 requires a beta energy of > 40 keV and therefore would not detect tritium contamination.
- The intensity of the radiation (dose rate or activity levels)
- Interference from a mixed radiation field
- Background radiation discrimination.
- Environmental factors, such as radioactive gases, moisture, or temperature, affect instrument response
- Procedural requirements.

To ensure the proper selection and operation of instruments, the instrument operator must understand the operating characteristics and limitations of each instrument available for use.

A distinction should be made between instruments used to measure radiation and those used for contamination. The following table highlights some important differences.

	Radiation	Contamination
Typical Units	mrem/hr	cpm
Ideal Mode	Current (integrating dose)	Pulse (discriminating types)
Typical Window	7 mg/cm^2 (dead skin)	1 mg/cm2 (thin as possible)
Types of Radiation	gamma, beta, neutron	beta, alpha, gamma
Ideal Materials	Tissue equivalent	varies

A contamination instrument reads out in counts per minute (cpm), and based on the detector geometry measures the total number of events seen by the detector, regardless of their energy. In order to determine disintegrations per minute (dpm) efficiencies must be calculated using a known source. (cpm / efficiency = dpm)
Radiation that does not penetrate a 7 mg/cm^2 window will not penetrate the dead layer of skin, therefore it cannot be detected, thus cannot be reported as deep dose.
In contrast, contamination that is ingested, inhaled, or injected through wounds contributes a dose even if the radiation is not penetrating the detector's window; consequently contamination monitors have windows that are as thin as possible, typically about 1 mg/cm^2. Ideally, an external radiation monitor is tissue equivalent, responding in the same way as human tissue, and so reports a smaller dose from low energy gammas than from high energy gammas.

As the instrument inventory ages and is replaced, cord replacement has become more difficult. The older instruments and detectors in the inventory use a cable connector type (BNC) that is different than the connector type used on the newer instruments and detectors. This new

connector type (MHV) is not compatible with the older instruments and detectors. This has resulted in the need for three different cables. A cable that has BNC connectors at both ends, a cable with MHV connectors at both ends, and a hybrid connector that has a BNC connector at one end and a MHV connector at the other. The individual replacing the cable must ensure that the correct replacement is used when changing a damaged cable.

☞2.17.02	Describe the following features and specifications for commonly used count rate meter probes used at your site for beta/gamma and/or alpha surveys: a. Detector type b. Detector shielding and window c. Types of radiation detected/measured d. Energy response for measured radioactivity e. Specific limitations/characteristics.

COUNT RATE METER HAND PROBES

LUDLUM MODEL 44-9; ALPHA, BETA, GAMMA DETECTOR

The Model 44-9 GM (Pancake) detector will detect alpha, beta, and gamma radiation. Its size and shape provide easy handling for surveying or personnel monitoring. The detector is energy dependent, over responding by a factor of six in the 60 keV to 100 keV range when normalized to Cs-137.
The thin mica window is protected by a 79% open stainless steel screen. The GM tube can be easily removed for replacement.

The GM detector operates between 850 – 1000 volts. The Model 44-9 will operate with any Ludlum instruments or equivalent instruments that provide 900 VDC and an input sensitivity of approximately 30 mV or higher.
There are other specialty probes similar to the Model 44-9 probe like the Eberline HP-210T probe. This probe has tungsten shield covering the top and sides of the detector allows use in high background areas. Due to the similarity, this probe is not detailed in this study guide.

HP-210T (Tungsten) and HP-210 Aluminum

The EBERLINE HP 260 probe includes an aluminum housing with an extended handle and resembles the Ludlum Model 44-9 GM probe in appearance and operation.

Detector Type (Ludlum Model 44-9)

The detector is a sealed Geiger-Mueller (GM) "pancake" detector. A "pancake" detector has a radius or width that is much larger than the depth of the detector. The shielded hand probe contains the GM detector which has the mica window protected by a wire or stainless-steel etched screen. The fill gas in the GM tube is halogen-quenched argon.

The operating voltage for the GM detector is between 850 – 1000 volts. The detector has an 80 μs resolving time which is defined as the minimum time that must elapse after the measurement of an ionizing particle before a second particle can be measured.

Detector Window and Shielding

The thin detector window is 1.4-2.0 mg/cm^2 mica and is protected by the screen which is 79% open. Mica windows must be used instead of Mylar, because the Mylar will react with the halogen quench gas. The window has active surface area of 15cm^2.

Types of radiation detected/measured

The detector responds to alpha, beta, gamma and X-ray radiation of minimum energies.

- alpha > 3 MeV

Detector must be close enough to the source of alpha particles to prevent alpha particle attenuation in the air between the source and the detector. Due to the window that stops alpha particles of <3 MeV, the instrument is generally considered to be a beta / gamma detector only.

- beta > 40 keV

This prevents the detection of low energy beta particles, such as the beta particle from the decay of tritium (E_{max} = 18.6 keV).

- gamma > 6 keV

Photon radiation, such as gamma or X-ray, can interact in the detector walls and the fill gas to create a pulse. However, the probability of interaction is small due to the shallow depth of the detector and therefore the efficiency for photon radiation is small.

Energy response for measured radiation

Typically, a conservative beta efficiency of 10% is assigned. Therefore, to convert the cpm reading to a dpm value, the meter reading is multiplied by ten (dpm = cpm x 10). Efficiencies for alpha and photon radiation are not typically quoted because the probes are not calibrated for either type of radiation. However, gamma efficiencies are low, about 1-2%, because of the

shallow detector depth. Alpha efficiencies are highly dependent on the particle energy and distance from the source, but can be as high as 20%.

Gamma sensitivity is approximately 3,300 counts per minute (cpm) per mR/hr for Cs-137.

Specific Limitations and Characteristics

Generally, environmental conditions, such as humidity and temperature, do not affect the response of the detector because it is sealed at a pressure slightly less than atmospheric pressure.

Use of the hand probe at proper frisking speeds and distances is extremely important to ensure accurate results. The probe should be used at a distance of no more than 1/2 inch and at a speed of 1 to 2 inches per second.
The mica window is extremely fragile and sufficient care must be taken to prevent any punctures which will ruin the detector.

The detector probe is not calibrated for alpha radiation; however, it may be used for indication of alpha emission from contamination, if used properly.
It is compatible with a large range of instruments which include general purpose survey meters, ratemeters, and scalers.

LUDLUM MODEL 43-92 ALPHA SCINTILLATION PROBE

The Model 43-92 is an alpha scintillation detector. With an active area of 100 cm2, a slim low-profile body, and a low background count rate, this detector is good for surveys when alpha contamination is suspected on personnel and equipment.

Detector Type

The detector is constructed using ZnS (Ag) powder applied to a thin layer of plastic. A 1.125 in (2.9cm) diameter magnetically shielded photomultiplier tube is contained in the handle.

Detector Window and Shielding

The thin detector window is 0.8 mg/cm^2 Mylar and is protected by the screen which is 88% open. The window has active surface area of 100 cm^2 while the open area is approximately 88cm^2.

Types of radiation detected/measured

The detector is sensitive to the full spectrum of alpha-emitting radionuclides.

Specific Limitations and Characteristics

Generally, environmental conditions, such as humidity and temperature, do not affect the response of the detector because of its construction. The detector requires protection from the elements and must be maintained in an environment with the following conditions:

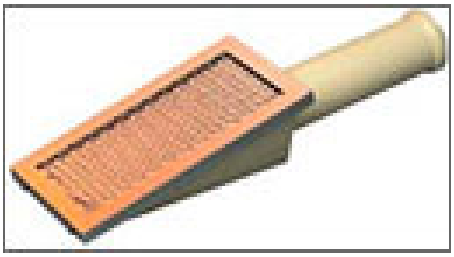
- 15^0C to +50^0C.

Use of the hand probe at proper frisking speeds and distances is extremely important to ensure accurate results. The probe should be used at a distance of no more than 1/4 inch and at a speed of no greater than 2 inches per second.

The Mylar window is extremely fragile and sufficient care must be taken to prevent any punctures which will cause light leaks and disable the detector. When performing an inspection (prior to use and with the unit turned on) turn the probe toward the light to ensure the integrity of the window. If the window has been penetrated the instrument will display a high or off scale reading.

It is compatible with a large range of instruments which include general purpose survey meters, ratemeters, and scalers.

PROBE DP6A OR DP6B



Featuring a large-area rectangular-shaped window, the DP6 probe series is ideal for monitoring personnel, tools, and work areas with efficient alpha/beta discrimination. The durable hex grille and field replaceable windows provide high reliability. The Dual Probe type DP6A is a hand held scintillation detector with 100 cm2 sensitive area for monitoring alpha and beta contamination. The A and B versions differ only in the type of connector used: The DP6A uses BNC and DP6B uses MHV.

Detector Type

The detector is a large, dual phosphor (ZnS/BC400) scintillation probe in a light alloy housing. The scintillation phosphor, mounted behind the window, is a layer of silver activated zinc sulphide on a thin sheet of BC400 transparent plastic. A photomultiplier tube and a thick film resistor network are contained in the handle of the housing.

Detector Window and Shielding

The probe is comprised of a painted aluminum alloy housing with a light-tight aluminized polycarbonate window protected by a stainless steel grille. The window is manufactured as two layers of polycarbonate. The window has a thickness of 3.5 μm.

Types of radiation detected/measured

The probe will detect both alpha and beta radiation

Specific Limitations and Characteristics

Care should be used when surveying with the DP-6 probe. Due to the thin layer of polycarbonate covering the scintillation probe, the window can be easily punctured allowing light to contact the detector surface. When performing an inspection (prior to use and with the unit turned on) turn the probe toward the light to ensure the integrity of the window. If the window has been penetrated the instrument will display a high or off scale reading.

☞2.17.03	Describe the following features and specifications for commonly used count rate instruments used at your site. a. Types of detectors available for use b. Operator-adjustable controls c. Specific limitations/characteristics.

COUNT RATE INSTRUMENTS

LUDLUM MODEL 2A SURVEY METER

The Model 2A Survey Meter is a portable survey instrument having the additional feature of an audio and visual alarm. The alarm circuit is adjustable from a meter scale deflection of zero to off scale for each range multiple. The meter scale presentation is 0-500 counts per minute (CPM) with a total range of 0-50,000 CPM.

The unit body is made of cast aluminum, including the meter housing. Other operating features of the instrument include a speaker mounted to the instrument can with an audio ON-OFF capability, fast-slow meter response, meter reset button, a 5-position switch for selecting battery check or scale multiples of Xl, Xl0 and Xl00. Each range multiplier has its own calibration potentiometer.

Types of detectors available for use

Any G-M probe offered by Ludlum will operate on this unit as well as many of the scintillation detectors. The instrument is set for 900-volt, G-M tube operation. For special requirements, it may be adjusted for operation with any G-M or scintillator tube between 400 and 1500 volts. The

default G-M detector has the following parameters.

Operator adjustable controls

RANGE MULTIPLIER SELECTION SWITCH is a 5-position switch marked OFF, BAT, X100, X10, Xl. Turning the range selector switch from OFF to BAT position provides operator a battery check of the instrument. A BAT check scale on the meter provides a visual means of checking the battery status. Moving the range selector switch to one of the range multiplier positions (Xl, X10, X100) provides the operator with an overall range of 0-50,000 CPM. Multiply the scale reading by the multiplier for determining the actual reading.

AUDIO ON-OFF TOGGLE SWITCH: In the ON position operates the speaker, located on the left side of the instrument. The frequency of the clicks is relative to the rate of the incoming pulses. As the count rate increases the audio frequency will become higher pitched. To reduce battery drain, the audio should be turned OFF when not required.
FAST-SLOW TOGGLE SWITCH: Selecting the FAST position of the toggle switch provides a 90% of final meter reading in 4 seconds. In SLOW position, 90% of final meter reading takes 22 seconds. In "F" position there is fast response and large meter deviation. "S" position should be used for slow response and damped meter deviation.

Specific limitations/characteristics

Three linear ranges: From 0 to 50,000 counts-per-minute (CPM)
Meter scale presentation - 0 to 500 CPM with range multiples of Xl, XlO, XlOO.
Alarm indication: Audio and visual indication when above alarm threshold.
Alarm range: Zero to off scale for each range multiple.
Response: 4 or 22 seconds at 90% of final reading.
Linearity: Plus or minus 5% full scale.
Calibration stability: Less than 15% variance to battery end point.
Temperature operable from 32°F to 150°F. This could present a problem when using this instrument since INL often experiences temperatures below freezing.

LUDLUM MODEL 3 SURVEY METER

Ludlum Model 3 is a portable radiation survey instrument with four linear ranges used in conjunction with exposure rate or cpm meter dials. The Model 3 features a regulated high-voltage power supply, unimorph speaker with audio ON/OFF capability, fast/slow meter response, meter reset button, and a six-position switch for selecting battery check or scale multiples of X0.1, X1, X10, and X100. The unit body and meter housing are made of cast aluminum and the can is 0.090” thick aluminum. Unit is operated with two “D” cell batteries for operation from 5^0F to 122^0F.

Types of detectors available for use

Any GM probe offered by Ludlum will operate on the unit as well as most Ludlum scintillation type detectors. Among the detectors discussed in this chapter, the Ludlum Model 44-9; Alpha,

Beta, Gamma Detector and the Ludlum Model 43-92 Alpha Scintillator Probe could both be attached to this meter.

Operator adjustable controls

- Instrument Selector Switch
- A six-position switch marked OFF, BAT, X100, X10, X1, X0.1. This switch is used to test the battery condition as well as set the range the instrument will operate on.
- Audio ON/OFF Switch
- Fast / slow meter response Switch
- Meter reset button,

Specific limitations/characteristics

Response: Toggle switch for Fast (4 seconds) or for Slow (22 seconds) from 10% to 90% of final reading.

Reset: Push-button to “zero” the instrument.

Power: Uses 2 “D” cell batteries housed in a sealed compartment that is externally accessible.

Battery Life: Typically 2000 hours with alkaline batteries.

End-of-Battery Life Warning: At 2.1 Vdc the meter needle will drop to the edge of the BAT TEST or BAT OK area when the meter selector switch is moved to the BAT position. At 2.0 Vdc, a steady audio tone will be emitted to warn the user about the low battery condition.

Meter: Typical meter dials are:

- 0-2 mR/hr
- 0-20 uSv/hr
- 0-5k cpm

Combination of exposure rates (0-2 mR/h or 0-20 uSv/hr), cpm, and BAT TEST.

THERMO ELECTRON'S SHM4A SINGLE HAND ALPHA MONITOR

The Thermo Electron Corporation's SHM4A is a single hand monitor for monitoring personnel in areas where alpha-emitting radionuclides may exist. Each monitor consists of an alpha scintillation detector with a ZnS (Ag) phosphor and thin mylar protection window protected by a robust grille, and electronics to generate the detector HV and to process the radiation signals.

Detector Type

Each monitor consists of an alpha scintillation detector with a ZnS(Ag) phosphor.

Detector Window and Shielding

Each monitor is manufactured with a thin mylar window protected by a robust grille. The thin detector window is 1.2 mg/cm^2 Mylar; it is protected by a 6 mm thick hexagonal mesh grille. The window has an effective surface area of 260 cm^2 (205 x 127 mm).

Types of radiation detected/measured

Due to the very thin (1.2 mg/cm^2) window, detector is sensitive to the full spectrum of alpha-emitting radionuclides

Specific Limitations and Characteristics

The monitor has a sensitive 260 cm^2 scintillation probe and is autonomous as it has no user controls. It assures hand positioning and has bright, clear user displays.

Proper hand positioning is maintained by sensors which guide the user via a recheck display light. Additional lights are provided to indicate Ready, Monitoring, Clear, Alarm and Fault.

The detector requires protection from the elements and must be maintained in an environment with the following conditions: +5 to +40^{0}C, up to 85% relative humidity, non-condensing.

The SHM4A has:

- High sensitivity and uniformity

- Long counting plateau to ensure excellent long-term stability
- Good tolerance of high humidity
- No loose external cables

RES button provides a rapid means to reset the meter to zero

HV Test Button displays the detector voltage on the meter when depressed

-
- Operates on AC power or with a built-in 6 volt sealed lead acid rechargeable battery
- Battery life is typically 8 hours and battery condition can be checked on meter
- Battery is continuously trickle charged when instrument is connected to line power and turned on

View of Back

LUDLUM MODEL 177 SERIES

The Ludlum Model 177 series count rate meters' electronic circuitry allows for use of scintillation, and GM detectors. Model 177 is vailable in conjunction with alpha, beta-gamma, and alpha-beta-gamma detection probes. The instrument could be placed at specific locations for personnel contamination monitoring.

The Eberline RM-25, a less used count rate meter, is very similar to the Ludlum Model 177 in operation is. One important difference is the temperature range of the RM-25: Temperature: 0 to 50° C (32 to 122° F) compared to the Ludlum Model 177: Temperature range from -4° F(-20° C) to 122° F(50° C). The Ludlum Model 177 may be certified for operation from -40° F (-40° C) to 150° F (65° C).

Because the EBERLINE RM-25 is very similar in operation, it is not detailed in this study guide.

Eberline RM-25

Types of detectors available for use (Ludlum Model 177)

Any GM probe will operate on the unit as well as most scintillation type detectors. Among the detectors discussed in this chapter, the Ludlum Model 44-9; alpha, beta, gamma Detector and the Ludlum Model 43-92 Alpha Scintillator Probe could be attached to this meter. Both, the Eberline model HP-210 and HP-260 probes, are used with this instrument.

Operator adjustable controls

Meter face readout of 0-500

Range multiplier selector switch is a six position switch

1. OFF
2. BATT
3. X1
4. X10
5. X100
6. X1,000

Audible click per radiation incident volume control adjustment

Fast-Slow toggle switch provides for meter response time selection

- Slow - response time of 22 seconds for 90% of final reading
- Fast - response time of 4 seconds for 90% of final reading.

RES Button provides a rapid means to reset the meter to zero

An 11 position Alarm Set Selector Switch is used to select a predetermined alarm threshold (0.5 to 500) at 100 cpm over background

Specific limitations / characteristics

Operates on AC power or with a built-in 6 volt sealed lead acid rechargeable battery

Battery life is typically 50 hours and battery condition can be checked on meter

Battery is continuously trickle charged when instrument is connected to line power and turned on.

Temperature range from -4° F(-20° C) to 122° F(50° C)
May be certified for operation from -40° F(-40° C) to 150° F(65° C)

NE ELECTRA

Types of detectors available for use

The ELECTRA is a portable, digital, ratemeter for use with a variety of GM and Scintillation probes for the measurement of radioactive contamination and radiation. The instrument is primarily used with the DP-6 probe which gives the instrument both beta and alpha detection capability. With NE Technology DP-6 Dual Scintillation probes, alpha and beta contamination can be monitored simultaneously, with separate tones on the sounder and independent alarm levels for each particle type. The display of rate can be selected to be for either type of particle or for the sum of both.

Probes can be connected to the unit's analog board via a connector protruding at the far end of the unit below the handle.

Operator adjustable controls

The NE ELECTRA is an advanced, digital, field instrument that requires in depth instruction prior to operation. It is programmed with a number of soft touch switches located on the top of the instrument. Initial setup prior to use by the operator determines what the instrument will detect and how it will display the information as it processes the data. In order to simplify use, many of the features of this instrument are "locked" out during calibration by the HPIL facility. The features that are "locked" out or "inhibited" are indicated in the following text with an asterisk.

Specific limitations/characteristics

Display of measured rate is in both "analogue" and digital format on a high contrast Liquid Crystal Display. The display is auto ranging and capable of displaying counts per second (cps), or counts per minute (cpm), for count-rate measurements, Bq, disintegrations per minute (dpm) and Bq/cm^2 for contamination measurements. Equipped with the appropriate probes, the instrument could be used for dose-rate measurements displaying in SVs per hour or Roentgens per hour.
*At the ICP, the CPM mode is locked and, therefore, it is the only mode used. The "analogue" display is in the form of a bar graph which has a logarithmic scale covering three decades. The display has a backlight for use in low light conditions, which is operated by a key on the front panel.

Audible indication of measured rate is given by an internal sounder and an external socket is provided at the handle end to enable the audible output to headphones.

Automatic Response Mode

In order to create a smooth "analog" signal, the erratic digital output is electronically dampen by averaging 1 second counting period over and up to 16 seconds. Thereafter, a rolling average over 16 seconds is maintained for steady count rates and for count rates below 6 counts per second.

The response time will be less than 2 seconds for significant changes, i.e. > 3 sigma above 6 cps and 11 seconds to 63% for lower rates and for smaller changes.

Integrate Mode

A separate "integrate mode" allows integration over a pre-settable time period in the range 10s to 5000s in 10s steps. *The ICP sets the instruments to 60 second integrate.

Background

*The ICP sets the instrument to allow the automatic background subtracting feature.

Digital

Four (4) digits with 3 decimal points show the measured rate to 3 significant digits. Actual displayed values on each of the ranges are limited by the range changing and software but the display limits are; 0.01 - 99.9, 01 - 999, 1.0 - 9990

Unit of Measurement

- Count Rate Monitoring - cps, cpm (set to **cpm** only), kcps, kcpm
- Contamination Monitoring - Bq, dpm, Bq/cm2 with prefixes of k.
- Radiation Monitoring - R/h or Sv/h with prefixes of n, /l, m, k.

The range and units displayed will be dependent on the probe used and is set by the SET UP parameters.

Sounder On

A sounder symbol is displayed.

Battery Low

A battery symbol is displayed when the battery voltage drops below a nominal 3.4 volts. Only 8 hours usage will be available once the symbol first appears.

Inhibit

An inhibit symbol is displayed if a parameter under the SET UP key is inhibited to the USER.

Set Up Mode Number/Alarm

A 7 segment indicator shows the set up mode number and displays II A" in alarm condition in normal operation.

IX, P, IX + P

Shows which particle type is being displayed in the Dual Probe mode only.

Display Illumination

A backlight is provided for the display which allows it to be read in low levels of illumination. The backlight stays on for 5 seconds after pressing the key. Three presses of the key in quick succession will enable the backlight to remain fully on until the backlight key is pressed again.

E-600 DIGITAL SURVEY METER

The E-600 (shown below) is similar in operation to the Electra. At ICP it is usually found attached to a REM Ball for the measurements of neutrons. This instrument is mentioned in the Radiation Survey Instrumentation chapter.

☞2.17.04	Describe the following features and specifications for commonly used personnel contamination monitors at your site. a. Detector type b. Detector shielding and housing c. Types of radiation detected/measured d. Specific procedures for source checks e. Specific procedures for sample counts.

PERSONNEL CONTAMINATION MONITORS

PERSONNEL CONTAMINATION MONITOR PCM-1B

The PCM-1B is a multi-detector personnel monitor. As a “semi-cylindrical” envelope, incorporating 15 thin gas-flow proportional detectors, it is an effective personnel contamination monitor. The software enables the system's detectors to be utilized in conjunction, reducing detection dead zones. Background is reduced by the thin detector design.

Detector type

PCM-1B has fifteen (15) independent gas-flow proportional detectors. The counting gas is P-10 (90% Argon, 10% Methane).

Detector shielding and housing

The detectors are held in the aluminum housing of the instrument. Detectors are distributed so that, almost, the entire body areas are covered. Thus two positions of the body are necessary for contamination survey (see below). A protective screen covers all detectors. The screen is made of etched stainless steel and provides 83 % opening to the detectors.

Types of radiation detected/measured

The PCM-1B is capable of detecting both beta and alpha contamination. Most units are setup for beta contamination monitoring only. When requested it can be setup to perform alpha monitoring as well.

The instrument is efficient to 28% for Cs137, and 12% for Pu239. It is calibrated/checked by a 4 inch-diameter disc Cs137 and/or 4 inch Pu239 (when required) source in contact with the screen.

Procedures for source checks

Source checks are performed weekly, or following maintenance or repair of the PCM. The source check consists of exposing each detector to a known source which should cause an alarm in the exposed detector. If any detector should fail to respond the unit is tagged out of service.

Procedures for Contamination Detection

The following narrative is a walkthrough of the PCM-1B in operation

The unit performs two-part personnel whole body survey by performing a right side then left side personnel body survey.

- Ultrasonic motion sensor detects movement of person toward monitor
- Background check is suspended
- Display reads - "STEP UP - INSERT RIGHT ARM"
- Placement of arm in arm cavity initiates personnel monitoring routine
- Display reads - "COUNTING RIGHT SIDE"
- Counting continues for duration of specific counting time
- If no alarm levels detected, unit beeps and displays clearance
- Display reads - "RIGHT SIDE OK -- INSERT LEFT ARM"
- Placement of left arm in cavity initiates monitoring
- Display reads - "COUNTING LEFT SIDE"
- Counting continues for duration of specific counting time
- If no alarm levels detected, unit beeps and displays clearance
- Display reads - "COUNT COMPLETE, YOU MAY PASS"
- Display accompanied by chime and the LED extinguishes

If the individual is found to be contaminated the following will occur

- Activity in excess of alarm levels detected in either right or left side count
- Alarm alert sounds at end of count time
- Appropriate display appears - "ALARM: ZONE 1 - ZONE 2 - ZONE 3," etc.
- Alarm and display continue for specified alarm hold time

- Alarm stops and display reads - "CONTAMINATED -- PLEASE STEP OUT."

The instrument also requires that the user be correctly aligned within the unit. If not then the following sequence would be activated

- Arm withdrawn prior to preset count time completion
- Alarm alert sounds
- Display reads - "COUNT INCOMPLETE **RECOUNT**"
- Reinsertion of arm restarts count

Specific limitations/characteristics

Monitors, measures and stores background values for all detectors

Checks for high background alarm levels

Checks for low or high count failures

Checks for low gas pressure conditions

In addition the unit is capable of recognizing a number of conditions that would render it unable to perform its designed function

Troubleshooting

PCM-1B message display will illuminate the trouble or diagnostic lights to identify various monitor malfunctions. Description of basic malfunction conditions listed below:

High background

- Background count rate in any zone(s) has increased above selected limit.
- Alarm light, high background light, sonalert, and "Channel Designation (i.e., 'Zone 1 ft): High Background" message are activated.
- Area should be checked for radioactive sources and/or detector checked for dirt, moisture or radioactive contamination.

High count fail

- Alarm light, trouble light, sonalert, and channel designation message are activated.
- Count capacity in any zone has been exceeded and PM Group to be contacted for troubleshooting.

Low count fail or low sensitivity fail

- Alarm light, trouble light, sonalert, and channel designation message are activated.
- May be the result of component failure or decrease/loss of decrease/loss of counting gas. Detector identified should be checked for leak in mylar. Leak in mylar can be sealed with scotch tape.
- Another possible cause is affects from a radiation emitting device located nearby.

Contaminated detector

- Contaminated detector light is activated along with contaminated detector message. Operation will continue with detector light on.
- Detector to be checked for contamination and decon around detector performed with masslin cloth.

Loss of gas pressure

- Two cylinders used but cylinder No. 1 used until empty. When empty, "Bottle No. 1 Empty" light activated and No. 2 put in use automatically.
- If both cylinders fail (empty) the trouble light, "Bottle No. 2 Empty," and display with indicate "Failure**Out of Gas" message will be activated.
- PCM-1B must not be used to monitor personnel with any trouble light illuminated. Monitor placed in "Out of Service" mode until cause corrected.

PERSONNEL CONTAMINATION MONITOR PCM-2

The enhanced counting geometry of the PCM-2 uses an array of 34 counting zones contoured in both the vertical and horizontal planes with multiple gas flow proportional detectors. This allows the PCM-2 to accurately measure alpha and low energy beta contamination over the entire surface of the body (see below). Earlier designs with flat banks of proportional detectors could only detect higher energy beta contamination. The new geometry, and its related ability to detect alpha contamination, allows the PCM-2 to measure and correct for the radon progeny radiation.

Detector type

Sixteen Separate gas flow proportional detectors subdivided into thirty-four counting zones. The counting gas is P-10 (90% Argon, 10% Methane).

Detector shielding and housing

The detectors are held in the aluminum housing of the instrument uniformly distributed so that all body areas are covered. Detectors are fast-rebuild type with "surface mount" anode wire installation that reduces sensitivity loss around edges.

Specific limitations/characteristics

The PCM-2 is the first whole body contamination monitor that can eliminate nuisance alarms caused by the radon progeny attached to clothing. Each of multiple counting zones has separate, simultaneous alpha and beta/gamma channels. Also up to 75 "Sum Zones" can be defined as 2, 3, or 4 adjacent detectors for maximum detection of contamination that is spread over multiple detectors. Sum zones reduce the possibility that contamination spread across detectors will be missed. A mathematical "Sum Channel" comprised of multiple detectors is used to detect low-level, widely distributed contamination. Individual detector channels within the PCM-2 are independently controlled by distributed microprocessors. A Pentium class computer is also built-in to provide a user-friendly interface for the system. This enhanced controller also simplifies calibration and maintenance of the unit, and presents test results clearly to the user in an easily understood graphic format.

Procedures for source checks

Performance checks are performed weekly or following maintenance or repair of the PCM. The source check consists of exposing each detector to a known source which should cause an alarm in the exposed detector. If any detector should fail to respond the unit is tagged out of service.

Procedures for Body Contamination Survey

The procedure for use of the PCM-2 is quite similar to the operation of the PCM-1B. The individual steps into the unit and follows much of the same sequences as in the other monitor.

EBERLINE PM-6

- Microprocessor based radiation monitor using gas-flow proportional detectors for whole body contamination scans.
- Two basic types of PM-6s are typically used.

PM-6A

- Uses eleven gas-flow counters to detect beta-gamma contamination.
- Same basic operating characteristics as PCM-1B.
- Source checked daily using beta-gamma source.

PM-6A-2

- Uses fifteen gas-flow counters to detect alpha or beta-gamma contamination.
- Additional detectors used in hand pods to increase ability to detect hand contamination.
- Hand and foot detectors sensitive to alpha as well as beta-gamma contamination.
- Source checked daily using alpha and beta-gamma sources for both hand and foot detectors.
- Beta-gamma source is used on body detectors.
- Source checks and troubleshooting PM-6 is same as PCM-1B.

☞ 2.17.05 Describe the following features and specifications for commonly used contamination monitors used at your site (tool, bag, laundry monitors).

a. Detector type
b. Detector shielding and window
c. Types of radiation detected/measured
d. Energy response for measured radiation
e. Specific limitations/characteristics.

OTHER CONTAMINATION MONITORS

This objective is not applicable to RCTs performing work at the ICP. Although contamination monitors such as the NNC WGM-10 Waste Curie Monitor and Eberline BWM-10 bag waste monitor may be employed at ICP, their use is not the responsibility of RCTs.

SUMMARY

In this lesson, we have covered contamination monitoring instruments in relation to types used, purpose of, radiation monitored, operational requirements, and specific limitations/characteristics for use. The RCT uses this information to identify and assess the hazards presented by contamination and establish protective requirements for work performed in contaminated areas.