APPENDIX D

IONIZING RADIATION MONITORS AND METERS

The following sections contain a brief description of the types of instruments that may be used for monitoring exposures to ionizing radiation and radioactive materials.

A. SURVEY METERS

Application and Principle of Operation

Radiation survey meters are used to locate and quantify sources of ionizing radiation or to quantify the exposure rate from sources of ionizing radiation. To assess the quantity of radioactive materials present, survey meters are typically calibrated to measure counts per minute (cpm). To measure the exposure rate from gamma (γ) or X radiation sources, survey meters are calibrated to measure roentgens per hour (R/h). Most survey meters have either gas filled detectors or scintillation detectors. Not all survey meters are configured to measure all radiation types. Survey meters must be chosen based on the type and energy of the radiation you expect to measure and whether you wish to measure cpm or R/h.

Calibration

Calibration is performed by the manufacturer on a periodic (usually annual) basis.

HRT Availability

1. Ludlum Model 3 with 44-9 Pancake GM Detector

The Ludlum Model 3 is a general purpose survey meter fitted with a pancake Geiger Mueller (GM) detector capable of measuring alpha (α), beta (β), γ, and X radiations. This instrument will measure count rates over a range of 0–500,000 cpm.

2. Ludlum Model 2360 with 43-93 Alpha/Beta Scintillator

The Ludlum Model 2360 is a survey meter capable of measuring and discriminating between α and β radiations. It is fitted with a Ludlum 43-93 alpha/beta scintillation detector. The meter will measure count rates over a range of 0–500,000 cpm.

3. Ludlum Model 192 MicroR™ Meter

The Ludlum Model 192 is a low level (μR/h) γ and X radiation exposure rate meter. The meter has an internal sodium iodide detector capable of measuring dose rates between 0 and 5,000 μR/h.

4. Thermo Scientific® FH40GL Dose Rate Meter with FHZ732GM Pancake Probe

The FH40GL is a stand-alone radiation survey meter equipped with an internal proportional detector capable of measuring γ and X radiation exposure rates from 1 μR/h–10 R/h. The unit is also equipped with an FHZ732GM pancake GM detector capable of measuring count rates from α, β, and γ radiations over a range of 0.01–100,000 counts per second.
5. **Thermo Scientific® FH40TG Teleprobe™**

The FH40TG telescoping probe can be used with the FH40GL to measure $\gamma$ and X radiation exposure rates over a range of 10 $\mu$R/h–1,000 R/h. The probe is equipped with two GM detectors that can be extended up to 13 feet away from the user, allowing exposure rate measurements to be made at a distance from the source.

6. **Thermo Scientific® RO-20 Ionization Chamber**

The RO-20 is capable of measuring exposure rates from $\beta$, $\gamma$, and X radiations. The instrument is equipped with an air filled ionization detector capable of measuring exposure rates up to 50 R/h.

7. **Thermo Scientific® PM1703M Gamma Pager**

The PM1703M is a pager-sized survey meter that can be worn on the belt. The meter contains a cesium iodide scintillator-photodiode detector capable of measuring $\gamma$ and X radiation. The instrument will measure exposure rates from 0–5,000 $\mu$R/h. The PM1703M is a highly sensitive instrument that can be set to alarm when the background varies by a user-set factor. This meter can be used to warn the user that he/she has entered a radiation area that is above background radiation levels.

**B. SCALARS**

*Application and Principle of Operation*

Scalars are used to analyze samples of radioactive material and to quantify the amount of material present. They are often used to measure the amount of radioactive material in air samples, wipe samples, and nasal swabs. Scalars use the same detector types used in survey meters. These instruments can typically be set to count a sample for a specified time.

*Calibration*

Calibration is performed by the manufacturer on a periodic (usually annual) basis.

*HRT Availability*

1. **Ludlum Model 3030 Alpha/Beta Scalar**

The Ludlum Model 3030 is a dual alpha/beta scalar used for sample counting. The instrument has a silver-activated zinc sulfide [ZnS(Ag)] coated scintillation detector capable of discriminating between $\alpha$ and $\beta$ radiations. The readout on the front of the instrument reports both $\alpha$ and $\beta$ counts for the specified period. Counting time can be set from 0.1–30 minutes.

2. **Ludlum Model 2000 Scalar with 43-10 Alpha Sample Counter**

The Ludlum Model 2000 scalar with 43-10 sample counter is capable of counting samples for $\alpha$ particle emissions. The sample counter has a ZnS(Ag) scintillation detector. Counting time can be set from 6–990 minutes.
3. **Thermo HandECount Scalar**

The HandECount is a battery or AC powered sample counter used for determining the $\alpha$ and $\beta$ activity present in a sample. The instrument is controlled by a Palm™ hand-held computer platform and operating system which communicates with a standard modular detector board to perform all counting operations. All data is automatically logged to a file for later retrieval to a PC. The HandECount will report both $\alpha$ and $\beta$ counts for a sample.

**C. ELECTRONIC PERSONAL DOSIMETERS**

*Application and Principle of Operation*

Electronic personal dosimeters are used to measure the dose received by an individual. They are normally worn on the front of the body in the chest area. Most electronic dosimeters measure the deep dose equivalent (Hp(10)) to $\gamma$ radiation. Some electronic dosimeters also measure the shallow dose equivalent (Hp(0.07)). Most electronic dosimeters allow the user to set alarms for integrated dose and/or dose rates.

*Calibration*

Calibration is performed by the manufacturer on a periodic (usually annual) basis.

*HRT Availability*

1. **Thermo Electronic Personal Dosimeter (EPD) Mk.2**

The Thermo EPD Mk.2 is an electronic dosimeter capable of measuring Hp(10) (deep dose) and Hp(0.07) (shallow/skin dose). It is sensitive to $\gamma$ and X radiations for Hp(10) measurements, and is sensitive to $\gamma$, $\beta$, and X radiations for Hp(0.07) measurements. Alarms can be set for accumulated doses and for dose rates for both Hp(10) and Hp(0.07).

2. **Rados RAD-60 Electronic Personal Dosimeters**

The Rados RAD-60 is capable of measuring Hp(10) from $\gamma$ and X radiations. Alarms can be set for both dose and dose rate.

**D. SPECTROSCOPY**

*Application and Principle of Operation*

Portable handheld radiation spectroscopy instruments allow the user to identify radionuclides. These instruments typically use a sodium iodide detector with a multichannel analyzer to measure the energy spectrum emitted by a radioactive source. The instrument compares the spectrum to a library of spectra and provides the user with a list of likely sources. Spectra can also be downloaded to a computer if the user wishes to perform the spectral analysis manually or wishes to print the spectra for documentation.

*Calibration*

Calibration is performed by the manufacturer on a periodic (usually annual) basis.
HRT Availability

EXPLORANIUM™ GR-135N

The EXPLORANIUM™ GR-135N is a handheld isotope identification device. The GR-135N has a sodium iodide detector capable of identifying radionuclides, a GM detector for measuring exposure rate, and a solid state neutron detector. Spectra from the GR-135N can be downloaded to a computer for analysis and printing.

E. ELECTRET-PASSIVE ENVIRONMENTAL RADON MONITORING

Application and Principle of Operation

The Electret-Passive Environmental Radon Monitor (E-PERM) system is a passive integrating detector system for the measurement of radon (\(^{222}\text{Rn}\)) or thoron (\(^{220}\text{Rn}\)) concentrations in air. It consists of a charged Teflon® disk (electret), an open-faced ionization chamber, and an electret voltage reader. When the electret is screwed into the chamber, an electrostatic field is established and a passive ionization chamber is formed. The chamber is deployed directly in the area to be measured. Radon gas diffuses passively into the chamber and the \(\alpha\) particles emitted from the decay of radon ionize the air molecules. These ions are then attracted to the charged surface of the electret, and the charge on the electret is reduced. The electret charge is measured before and after the exposure with a portable electret voltage reader, and the rate of change of the charge (change divided by the time of exposure) is proportional to the concentration of radon in the area.

Calibration

Calibration factors are provided for each type of electret. Calibration factors are voltage dependant and instructions for calculating the calibration factors are in the E-PERM manual provided by the manufacturer.

HRT Availability

The HRT has 12 E-PERM chambers, electrets, and a voltage reader.

F. RADIATION PPE AND SHIELDING

In radioactively contaminated areas, PPE is typically used in order to prevent workers from becoming contaminated, and to minimize the spread of radioactive contamination. The choice of appropriate shielding for ionizing radiation depends on the type and energy of the radiations to be shielded. Alpha particles have very low penetrating power and travel only a few centimeters in air and will not penetrate the dead outer layer of skin. Shielding is generally not required for alpha particles because external exposure to alpha particles delivers no dose. Where particulates contaminated with alpha particles are present, HEPA-filtered respiratory protection is critical to prevent an internal dose. Beta particles can travel several meters in air and can penetrate several millimeters into the skin. Beta particles should be shielded using an appropriate thickness of low atomic mass (low-Z) materials such as aluminum or plastics (e.g., Plexiglas®). Shielding beta particles with high-Z materials should be avoided as this can result in production of secondary X radiation (i.e., bremsstrahlung radiation). Gamma and X-rays can travel kilometers in air and can penetrate deep into the human body or pass through it entirely. Gamma and X-rays are most efficiently shielded using an appropriate thickness of high-Z materials such as lead or steel, or with an appropriate thickness of concrete. Neutrons are most efficiently shielded using an
appropriate thickness of hydrogenous materials such as paraffin, water, or plastics, or with an appropriate thickness of concrete.

NOTE: The HRT also serves as the coordinator for OSHA's radiation SRT and can provide additional assistance and technical information regarding radiation measurements. Special precautions are also necessary to prevent exposure when working with radioactive materials, such as PPE and/or other work practices. Contact the HRT for more details.