IP3

GM DETECTOR CALIBRATION AND CHECK-OUT

1.0 PURPOSE

To describe the procedures for calibration and operational check-out of GM detectors.

2.0 RESPONSIBILITIES

- The Laboratory Manager or designee is responsible for assuring that this procedure is implemented.
- Health Physics personnel are responsible for calibrating the instrument.
- Laboratory personnel are responsible for following the part of this procedure dealing with instrument checkout.

3.0 EQUIPMENT

- Portable ratemeter-scaler: Model Bicorn Analyst, Bicron Corporation; or equivalent.
- GM detector: Model HP-260 (GM "Pancake"), or equivalent.

  Note: **The HP-260 detector face may be covered with a thin layer of tracing paper to provide a total thickness of 7 mg/cm^2 which will increase the degree of protection of the detector face from accidental puncture and contamination and shield alpha radiation contributions. If a shield is to be used, all calibration and operational check-out procedures should be performed with the shield in place.**

- Cable: MHV-MHV; or other connectors, as applicable.
- Record forms.
- Calibration sources.
- Check source.

4.0 PROCEDURE

4.1 Instrument/Detector Assembly and Electronic Set-Up

4.1.1 Attach the GM detector to a portable ratemeter-scaler.

4.1.2 Check battery conditions accordingly for the following instrument/detector combinations:

Analyst/HP-260: Turn the instrument to the bat. position. Check the bat. ok area of the display. The indicator should be in this area.

4.1.3 Adjust the high voltage to 900 volts.

4.2 Calibration Background Determination

4.2.1 Determine the detector background for one minute. If the background is between the ± 2σ acceptance limits of the established instrument/detector control chart average background, proceed with calibration. If the background value is between the 2σ and 3σ investigation limits perform two more background measurements. If both counts are within the 2σ limits, continue calibration. If the initial background measurement is outside of the ± 3σ limits, perform three additional one minute background measurements. If at least two out of the three additional measurements fall within the 2σ limits and the third measurement is less than the 3σ limit, proceed with calibration. Record the background and response limits.

If the above conditions are not met, then the instrument/detector combination must be removed from service until repairs can be made or the combination is evaluated for changes in instrument operational parameters or other factors. Establishment of a new control chart will then be required following any repair or modifications with the potential to affect the background range. Site specific and construction material-specific backgrounds will be determined in the field, as required to address the project objectives.

4.3 Efficiency Determination

4.3.1 Select a beta calibration source with energies representative of site contaminant(s). The source selected should be a large—area source—larger than the detector area—and which will provide a minimum accumulation of 10,000 gross counts (C_{s+b}) during the count interval. The typical count interval with available calibration source is one minute. Longer count times may be necessary, dependent upon calibration source activity. Calibration sources of Sr Y-90 and Tl-204 are to be decay corrected prior to use.

4.3.2 Place the detector on the source and accumulate the count. Record the source identification number, source gross count rate (R_{s+b}) and 2π surface emission rate, $q_{2\pi,sc}$, (in cpm) from the NIST Calibration Sheet on the Calibration Data Form.

Note: The $q_{2\pi,sc}$ is the 2π emission rate of the calibration source that is subtended by this physical probe area—i.e. to determine fraction of total source emission rate that corresponds to physical area of probe as follows:

$$\frac{2\pi\ source\ emission\ rate\ (cpm)\ x\ physical\ detector\ area\ (cm^2)}{source\ area\ (cm^2)}$$

4.3.3 Subtract the average control chart background count rate, R_b, from the calibration source gross count rate (R_{s+b} - R_b).

4.3.4 Calculate the instrument efficiency (ϵ_i), and round the results to two significant figures. (The instrument efficiency (ϵ_i) for an HP-260 typically ranges from 10 to 50% and is dependent upon source energies).

$$\epsilon_i = \frac{R_{s+b} - R_b}{q_{2\pi,\ sc}}$$

Record all information on the Calibration Data Form.

4.4 Check Source Reproducibility Determination

4.4.1 Position a beta-gamma check source (e.g., Co-60, Sr-90) on the detector. Accumulate the count for one minute. The check source used should provide a minimum count rate of 10,000 cpm. However, lower activity check sources may be used at the discretion of the site coordinator. Record the count rate and time. Remove the detector from the source. Reposition the detector and source and repeat the count. Repeat 10 times. Calculate the average value and the 3σ deviation. The 3σ value must be ≤ 10% of the mean. If it is not, the detector must be removed from source until repairs can be made. Calculate ± 5% of the mean. If the 3σ is less than 5% of the mean, use ± 5% of the mean as the acceptable check source response range. If the 3σ is between 5% and 10% of the mean, use the actual ± 3σ values as the acceptable detector check source response range. Record all information on the Calibration Data Form .

Note: This same check source is to accompany the calibrated instrument to the laboratory area.

4.4.2 Prepare an Instrument Operational Check-out Form. Enter the average check source count rate, the average background count rate (from the control chart), instrument efficiency (ϵ_i), and the count times on the first data line. Enter acceptable range limits for check source and background response (from control chart).

Note: This form accompanies the instrument to the laboratory area.

4.5 MDC Determination

Calculate and record the minimum detectable concentration (MDC) using the following formula:

$$MDC = \frac{3 + (4.65\sqrt{B})}{T \times \epsilon_{tot} \times G}$$

MDC = minimum detectable concentration level in disintegrations/minute/100 cm^2
B = background (total counts) in time interval, T (may be construction material- specific)
T = count time (min) to be used for field measurements
ϵ_{tot} = total efficiency = $\frac{counts}{disintegration} = \epsilon_i * \epsilon_s$

ϵ_i = instrument efficiency
ϵ_s = source efficiency
unless otherwise determined: ϵ_s= 0.5 for β_{max} greater than 400 keV (e.g. SrY-90) or
ϵ_s= 0.25 for β_{max} < 400 keV

G = geometry = $\frac{\text{physical detector area } cm^2}{100}$;

HP-260 detector area = 20 cm^2

This formula calculates the activity level in dpm/100 cm^2 which can be detected at the 95% confidence level.