IP2

ALPHA SCINTILLATION DETECTOR CALIBRATION AND CHECK-OUT

1.0 PURPOSE

To describe the procedures for calibration and operational check-out of alpha scintillation 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 Analyst, Bicron Corporation; or equivalent.
- Alpha detector: Model A50, Bicron Corporation; or equivalent.
- 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 alpha detector to a portable ratemeter-scaler.

Note: Instrument high voltage should be set at the previous HV plateau setting for section 4.1.2. through 4.1.4

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

Analyst: 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 Turn on instrument audio and direct detector face to a source of light to check for "light leaks". Light leaks are indicated by saturation of instrument due to high count rate. Repair or replace detector face as necessary.

4.1.4 Construct a Plateau Curve.

The operating voltage is determined based on the characteristics of a plateau curve. Curves are constructed once a year, after major repairs to a detector, and when a new detector is received. These curves are kept on file in the instrument room.

4.1.4.1 Place the detector on one of the alpha calibration sources having a 2π surface emission rate greater than 25,000 cpm.

4.1.4.2 Turn the high voltage down, then gradually increase voltage until the meter begins to register counts.

4.1.4.3 The speaker unit may now be turned off.

4.1.4.4 Accumulate counts for 1.0 minute.

4.1.4.5 Record voltage setting and count rate.

4.1.4.6 Increase voltage to next higher even multiple of 40 V.

4.1.4.7 Accumulate counts for 1.0 minute and record voltage and count rate.

4.1.4.8 Repeat 4.1.4.6 and 4.1.4.7 until the count rate begins to increase rapidly with increased voltage. Do not increase the voltage into the continuous discharge range as damage to the instrument/detector may result.

4.1.4.9 Prepare a graph of count rate vs. voltage. This graph should consist of a relatively flat section where there is little increase in count rate over a voltage range of up to several hundred volts.

This voltage range is called the plateau region of the detector.

4.1.4.10 Select a voltage at the midpoint to 3/4 of the plateau region as the operating voltage and indicate the value on the graph. Adjust the instrument voltage to this setting. (This operating voltage typically ranges between 720 and 920 volts.)

4.1.5 Record the predetermined operating voltage and threshold on the Calibration Form.

4.2 Calibration Background Determination

Determine the detector background count for 1 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 one minute 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 project objectives.

4.3 Efficiency Determination

4.3.1 Select an alpha calibration source. The source selected should be a large—area source—larger than the physical 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 sources is one minute. Longer count times may be necessary, dependent upon calibration source activity.

4.3.2 Place the detector on the calibration source and accumulate the count. Record the source identification number, source gross count rate (R_{s+b}) and the 2π surface emission rate, $q_{2\pi,sc}$, (in cpm) from the NIST calibration data 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 detector area—i.e. determine fraction of total source emission rate that corresponds to physical area of detector as follows:

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

4.3.3 Reverse the detector position and repeat the count.

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

4.3.5 Calculate the instrument efficiency (ϵ_i), for both detector/source arrangements, average the instrument efficiency obtained from the two measurements and round the result to two significant figures. (The instrument efficiency (ϵ_i) for an AC3-7 typically ranges 30 to 40%).

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

Record all information on the Calibration Data Form.

4.4 Calibration Check-Source Reproducibility Determination

4.4.1 Position an alpha check source (e.g., Th-230) 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 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 service 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 detector 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 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. Also enter acceptable range limits for the check source and background response (from the 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 = 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

$$\epsilon_{tot} = \text{total efficiency} = \frac{\text{counts}}{\text{disintegration}} \; ; = \epsilon_i * \epsilon_s$$

ϵ_i = instrument efficiency
ϵ_s = source efficiency
unless otherwise determined: $\epsilon_s = 0.25$ for alpha

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

A50 detector area = 50 cm^2

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