Technical Safety

RADIATION PROCEDURES MANUAL

Procedure Cover Sheet

Procedure Title: Calibration of Eberline Portable Particulate Noble Gas Monitor

Procedure Number: TSO-08-13-REV 1

Effective Date: July 1, 2008

Approved By: ________________________ Date: _____1 July, 2009______
Technical Safety Office Director

A. INTRODUCTION

The NRC requires that instruments used for quantitative radiation measurements to be calibrated periodically for the radiation measured (10CFR20.1501 (b)). These instruments are required to be calibrated at least annually, or following repair by personnel at the Technical Safety Office (TSO). Instruments at ISU, however, are calibrated semi-annually. Instruments for measuring exposure rates are calibrated for linearity of response on all useful ranges. Instruments used for contamination surveys are calibrated for detection efficiencies for various radionuclides, as well as for linearity of response. The detection efficiency will be recorded on the instrument probe.

B. PURPOSE

The purpose of this procedure is to describe the necessary steps that must be taken in order to properly calibrate the Eberline Portable Particulate Noble Gas Monitor and the Technical Associates Model BAM-3H Continuous Air Monitor.

C. REQUIRED MATERIAL(S)

Eberline Portable Particulate Noble Gas Monitor
Instrument User Manual
Foam Source Holder
Cs-137 Beta Standard Source
    Serial Numbers: 72999A-206 (0.1 µCi)
Am-241 Alpha Standard Source
    Serial Number: 72998A-206 (0.098 µCi)
Calibrated Mass Flow Meter (optional)

D. PROCEDURE

The portable particulate noble gas monitor (PNG) is calibrated by counting both beta and alpha sources in the noble gas and beta particulate chambers and then calculating efficiencies. The PNG air pump must be calibrated as well.

One will find the chambers on the bottom of the monitor. They look like steel cylinders with knobs that poke out and are held in place with a retaining bar. The beta particulate chamber is on the left and the noble gas chamber is on the right. The readout meters are on the top left of the interface. Each readout scale corresponds to a unique chamber, and they are labeled accordingly. There are switches located underneath plates next to the readout scales. The top ones are labeled ‘SUB’ and when activated will cause the monitor to subtract any counts coming in on the alpha detector.

PARTICULATE CHAMBER

1. Loosen the two knurled thumb knobs holding the retaining bar.
2. Remove the retaining bar.
3. Open the beta particulate chamber by pulling on the knobs and pulling out the cylinder.
4. The beta particulate chamber provides a measure of the beta activity on the filter paper. Insert the beta standard source in the filter holder. The filter holder is contained inside the chamber.
5. Record the value from the readout scale on the PNG monitor calibration sheet. Make sure there is subtraction occurring by switching ‘SUB’ to the on position prior to making the measurement.
6. Calculate and record the efficiency by dividing the count rate by the disintegration rate of the source.
7. The alpha particulate monitor is a measure of the alpha activity on the filter paper. Insert the alpha source into the filter holder, active side facing the detector.
8. Adjust the ‘SUB’ switch to off so that the value from the detector will be displayed.
9. Record the value from the readout scale.
10. Calculate and record the efficiency.

NOBLE GAS CHAMBER

The manufacturer recommends using a gas of known concentration, and calculating efficiency. However, in the event no such gas is available, one may use filter paper standards as done with the beta particulate chamber. If the latter method is used, one must devise a way to hang the sources near the detector (as close as possible). One such method is described in this procedure.

1. Remove the cylinder by pulling on the handle.

2. Tape the standard source(s) to one end of the foam source holder, facing the detector.
3. Insert the plug and source one inch away from the detector window. It is important to account for the inverse-square law when calculating efficiency using this distance.
4. Close the chamber
5. Record the count rate from the noble gas chamber's detector.
6. Calculate and record the efficiency.

AMBIENT RADIATION

There is also an area monitor located on the assembly (above the air pump, labeled DA1-1) that reads out on the noble gas channel. This too can be calibrated in a radiation field, such as the Cs-137 Shepard source downstairs. However, since the assembly is very heavy and cannot fit through the door to the Shepard room, the Shepard source must be moved to the hallway in order to calibrate the area monitor. This must be done when the building is empty after hours.

1. Move the PNG and 1 Ci Shepard source into the hallway by the beam lab.
2. Tape off entrances into hallway to ensure no one enters radiation area.
3. Set up the PNG monitor at a distance from the Shepard source so the rate meter scale reads 600 cpm.
4. Record the distance in the calibration sheet, to the nearest 16^{th} of an inch from the DA1-1 gamma meter.
5. Repeat steps 3 and 4 for 6,000, 60,000, and 600,000 cpm.
6. Return the Shepard source to its proper location.
7. Put the PNG in room B109.
8. Open up the Shepard 1 Ci file on tsoshare, and using the recorded distances calculate the expected exposure rate (in dpm).
9. Divide the cpm by dpm for each distance to calculate efficiency.
10. Use Excel to plot efficiency as a function of exposure rate. Include this in the calibration spreadsheet and in the calibration memo.

BACKGROUND SUBTRACTION

1. For each channel, switch the subtraction switch S101 to 'SUB' on each readout scale.
2. Adjust the subtraction level (LEVEL) potentiometer R104 (see instrument user manual in TSO for location) to subtract out approximately 90% of the meter reading when no radiation

exists from the following sources: Beta particulate, ^{131}I, or beta gas.

3. For the beta particulate subtraction turn on the air pump and allow Radon to stabilize on the filter paper (suggested >4 hrs).
4. Verify that the flow rate is at 60 +/- 5 liters per minute (lpm) as indicated by the mass flow meter on the front interface.
5. Note the meter reading on the readout scale and switch the subtraction switch S101 to 'SUB'.
6. Adjust the SUB LEVEL potentiometer R104 until the meter reading remains at 10% of the value noted above. This may take several minutes.
7. For the subtraction of the area monitor from the noble gas channel, record the noble gas' meter reading. Set switch S10 to 'SUB' then adjust potentiometer R104 until the meter reads 10% of the previous value.

SAMPLE FLOW

The sample flow rate is indicated by the flow meter in lpm. This reading is not a standard or mass independent measurement and must therefore be corrected for density and altitude.

1. Multiply the reading by the square root of the ratio of the operating absolute pressure to a standard atmosphere (29.92 inches of Hg).

   Standard Flow = Observed Flow x $\sqrt{\frac{operating\ absolute\ pressure}{29.92\ inches\ Hg}}$

   Where:
   Operating Absolute Pressure = Operating Gauge Pressure plus Atmospheric Pressure

   As an example, at an altitude of 4700 feet, the pressure is 25.19 inches Hg. If the operating pressure is 6 inches Hg vacuum as measured on the pump suction gauge (located on the panel mounted next to the pump), the operating absolute pressure is -6 + 25.19 = 19.19 inches Hg. Thus the correction factor would be:

   $$\sqrt{\frac{19.19}{29.92}} = 0.80$$

   If the observed flow is 75 lpm, the corrected or standard flow is:
   75 lpm x 0.80 = 60 lpm.

An alternate method is done with a calibrated mass flow meter.

1. Attach the meter to the intake hose of the pump.
2. While adjusting the air flow via the air flow regulator, record the changes in both the sample flow rate and the mass flow meter attached to the intake hose.
3. Plot these values on a scatter plot.
4. Calculate the ratio of the calibrated mass flow meter readings to the air flow readings, or use a linear regression and note the slope of the trend line. This calculation will give the correction factor to be used.

ALARM SETPOINTS

Check each channel's alert and high alarm set points.

1. For the alert alarm depress switch S6 to display the alert alarm set point on the readout scale.
2. Adjust the alert alarm potentiometer R23 until the set point decreases below the present meter reading. The alert (yellow) lamp should come on.
3. Reset the alert alarm to twice the background level.

   Note: If alarm lock switch is in the LOCK position, depress the alert alarm (yellow) reset push button on the front panel of the readout scale.

4. For high alarm press switch S6 upward to display the high alarm set point on the readout scale.
5. Adjust the high alarm potentiometer R24 until the set point decreases below the present meter reading. The high (red) alarm lamp on the readout scale should come on.
6. Determine the radionuclides present during operation of the PNG.
7. Determine the appropriate DAC value based on the radionuclides present.

   Note: This information is found in 10 CFR 20 Appendix B, Table 1 and is available online at http://www.nrc.gov/reading-rm/doc-collections/cfr/part020/appb/

8. Calculate count rate in counts per minute from the DAC value using the following equation:

$$Counts\ per\ minute = (DAC)(3.7X10^7)(Efficiency)(Corrected\ Flow\ Rate)(Yield)$$

Where:
Efficiency is based on the radionuclide present. Use the appropriate efficiency value calculated previously.

Use the *Corrected Flow Rate* calculated previously.
Yield is the fractional yield of a particular radiation emitted during the decay process.

9. Reset the high alarm to the appropriate value.

FINAL CONDITIONS

1. Fill out a calibration sticker.
2. Place the sticker on the monitor.
3. File the calibration sheet in the PNG file folder.
4. Compose a calibration data sheet and save it on tsoshare.

    - *Tsoshare*
    - *RPR Procedures*
    - *REVISED RPR PROCEDURES*
    - *Calibration Procedure*
    - *PNG Monitor*
    - Save As: Calibration Spreadsheet __(Month) (Year)___

5. Compose a memo of calibration for the user and attach the calibration data sheet.
    - *Tsoshare*
    - *RPR Procedures*
    - *REVISED RPR PROCEDURES*
    - *Calibration Procedure*
    - *PNG Monitor*
    - Save As: Calibration Letter __(Month) (Year)___

PERIODIC CALIBRATION CHECK

On-line calibration verification of the monitor may be accomplished quickly and dynamically during operation by correlating laboratory data with observed data.

1. At filter change time, analyze the spent filter (or a gas sample) in the laboratory for activity (or concentration).
2. Compare this data to the data from the monitor. Adjust the calibration constant of the corresponding channel accordingly, taking in account radioactive decay.

Note: This method is valid only if the laboratory methods of determination are more accurate than the air monitor. Since the beta detector has a definite change in efficiency with different beta energies, data from the laboratory analysis should include isotopic mix so this effect can be evaluated. Any changes to the calibration constant which are greater than that which is deemed reasonable should be cause for complete recalibration per original methods prescribed.

REFERENCES

10 CFR 20 1501(b)

10 CFR 20 Appendix B, Table 1

PORTABLE PARTICULATE NOBLE GAS MONITOR (PNG) TECHNICAL MANUAL

ATTACHMENTS

PNG CALIBRATION LETTER

CURRENT PNG CALIBRATION SPREADSHEET

REVISION TRACKER

Revision 1	July 1, 2009	Original Procedure