Colorado Procedure – Laboratory 5305-15

Standard Method of Test for

Leak Wipe Analysis for Nuclear Gauges

1. SCOPE

1.1 The Colorado Department of Public Health & Environment requires that all nuclear gauges be leak wiped. This condition within the Colorado Department of Transportation's Radioactive Materials License is set forth to enable the licensee to detect the presence of removable radioactive contamination. Leak wipes are also performed if a nuclear gauge is involved in an accident or if any CDOT personnel possess an unexplainably high radioactive exposure on their personnel dosimeters. Leak wipes are performed by the Region On-site RSOs using CP-L 5301 and submitted to CDOT Staff Materials and Geotechnical Branch's Nuclear Lab for analysis.

2. APPARATUS

2.1 Ludlum Model 2929 Dual Channel Scaler with 43-10-1 Detector. Make sure the annual calibration is up to date.

2.2 Leak Test Wipes Report completed by region on-site RSOs.

2.3 Leak Wipe Envelope with leak wipe filter paper enclosed.

2.4 Forceps

2.5 2.0 inch diameter aluminum planchet.

2.6 Leak Wipe Report Form.

2.7 High Voltage Adjustment Form.

3. HIGH VOLTAGE ADJUSTMENT

3.1 Connect the cable to the 43-10-1 detector and power on the Ludlum 2929 and allow to warm up for five minutes.

3.2 Determine the current activity of the calibration standards using the following formula:

$$A_t = A_0\, e^{\frac{-0.693t}{t_{\frac{1}{2}}}}$$

Where:

A_t =Current activity in decays per minute (dpm)

A_0 = Original activity in dpm

t = Age of standard in months

$t_{\frac{1}{2}}$ = Half-life of standard in months

Examples:

For the AM-241 standard on August 1, 2001

A_0 = 17.3 Bq or 1038 dpm on August 5, 1986

(1 Bq=1 decay per second)

t = 15 years or 180 months

$t_{\frac{1}{2}}$ = 458 years or 5496 months

$$A_t = 1038e^{\frac{-0.693*180}{5496}} = 1015dpm$$

For the CS-137 on August 1, 2001

A_0 = 14.5 Bq or 870 dpm on August 12,1986

t = 15 years or 180 months

$t_{\frac{1}{2}}$ = 30 years or 360 months

$$A_t = 870e^{\frac{-0.693*180}{360}} = 615dpm$$

3.3 Set the HV knob to 600 volts. The knob will have a setting of 2.40.

3.4 Place a new planchet in the sample chamber. Close and lock the sample chamber.

3.5 Perform and record a one-minute count. These counts are the background counts. Make sure to record both the alpha and beta counts.

3.6 Increase the voltage by 25 volts and repeat the procedure in Subsection 3.5 until the voltage reaches 900 volts. Every 0.10 on the knob is 25 volts.

3.7 Remove the planchet from the sample chamber and using the forceps place the CS-137 standard on a new planchet with the engraved side down. Place the planchet in the sample chamber. Close and lock the sample chamber.

3.8 Set the voltage to 600 volts. Perform and record a one-minute count. Make sure to record both the alpha and beta counts.

3.9 Increase the voltage by 25 volts and repeat the procedure in Subsection 3.5 until the voltage reaches 900 volts.

3.10 Remove the CS-137 standard and planchet and place the AM-241 standard on a new planchet with the engraved side down. Place the planchet into the sample chamber. Close and lock the sample chamber.

3.11 Set the voltage to 600 volts. Perform and record a one-minute count. Make sure to record both the alpha and beta counts.

3.12 Increase the voltage by 25 volts and repeat the procedure in Subsection 3.5 until the voltage reaches 900 volts.

3.13 Calculate the CS-137 (beta source) efficiency and the AM-241 (alpha source) efficiency where:

$$efficiency = \frac{cnts - bkgrd\ cnts}{current\ activity}$$

Definition:
counts- cnts
background-bkgrd

3.14 Calculate the CS-137 cross-talk where: $crosstalk = \frac{alpha\ cnts - alpha\ bkgrd\ cnts}{beta\ cnts - beta\ bkgrd\ cnts}$

3.15 Calculate the AM-241 cross-talk where: $crosstalk = \frac{beta\ cnts - beta\ bkgrd\ cnts}{alpha\ cnts - alpha\ bkgrd\ cnts}$

3.16 Pick the high voltage setting using the following criteria:

a) CS-137 2pi efficiency is greater than or equal to 28.00%.
b) AM-241 2pi efficiency is greater than or equal to 30.00%.
c) CS-137 cross-talk is less than or equal to 1.0%
d) AM-241 cross-talk is less than or equal to 10.0%
e) Alpha background count is less than 3 cpm
f) Beta background count is less than 80 cpm

When more than one voltage setting meets all the above criteria pick the one with the lowest AM-241 cross-talk.

4. LEAK WIPE ANALYSIS

4.1 The legal limit for removable radioactive material on a sealed source is 0.005 micro curies (µCi) or 11,100 dpm. The desired Lower Limit of Detection (LLD) is 0.00005 µCi. Use the following equation to determine the Alpha and Beta counting times for the desired LLD:

$$Count\ Time = \frac{2\sqrt{2} * 1.645\sqrt{bkgrd\ cnt}}{LLD * Efficiency\ * 2{,}220{,}000}$$

Round the calculated count time to the next whole minute and use the larger of the Alpha or Beta count times.

4.2 Take and average ten background counts at the voltage selected in Subsection 3.16 with a new planchet and a clean filter paper to calculate the LLD using the following equation:

$$LLD = \frac{2\sqrt{2}\ *\ 1645\sqrt{Bkgrd\ Cnt}}{Cnt\ Time *\ Efficiency\ *\ 2{,}220{,}000}$$

4.3 Calculate and record the alpha and beta cpm for 0.00005 µCi of contamination where:

$$alpha = 111 * AM - 241\ efficiency + alpha\ bkgrd\ cpm$$

$$beta = 111 * CS - 137\ efficiency + beta\ bkgrd\ cpm$$

Multiply the alpha and beta counts per minute by the count time determined in the procedure in Subsection 4.1. Any test with counts below these would be reported as 0.00005 µCi

4.4 Set the high voltage to the setting selected in Subsection 3.16 and the count time to the count time selected in Subsection 4.1.

4.5 Select an envelope and record the leak wipe test number on the Leak Wipe Report Form.

4.6 Open the envelope and with the tweezers place the filter paper on a new planchet with the "dirty" side up.

4.7 Place the planchet in the sample chamber. Close and lock the sample chamber

4.8 Perform and record a count. Make sure to record both alpha and beta counts. If the Alpha counts are lower than the Alpha counts for 0.00005 µCi, report 0.00005 µCi for Alpha. If the Beta counts are lower than the Beta counts for 0.00005 µCi, report 0.00005 µCi for Beta. If the counts are higher than the count for 0.00005 µCi then use the following equations to determine the measured activity:

$$Alpha\ \mu Ci = \frac{Alpha\ cnt - Alpha\ bkgrd\ cnt}{2{,}220{,}000 * cnt\ time * Am - 241\ efficiency}$$

$$Beta\ \mu Ci = \frac{Beta\ cnt - Beta\ bkgrd\ cnt}{2{,}220{,}000 * cnt\ time * Cs - 137\ efficiency}$$

4.9 If the measured activity is greater than 0.005 µCi, check your math and if it is still above 0.005 µCi rerun the test. If it still is above 0.005 µCi notify the CDOT RSO immediately

4.10 Remove the planchet from the sample chamber and place the filter paper back in the envelope with the tweezers.

4.11 Repeat the procedures in Subsections 4.4 through 4.9 until all leak wipes have been tested.

4.12 If the leak wipe analysis is not completed in one day then for each additional day of testing use the voltage determined in the procedure in Subsection 3.16 and perform and record a one-minute background count. Perform the calculations in the procedure in Subsection 4.3 and repeat the procedures in Subsections 4.4 through 4.10 until all leak wipes have been tested.

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