Contamination Assessment and Exposure Rate Measurements of ^{117m}Sn

This guide is written for veterinary licensees using ^{117m}Sn. Content includes specific guidance using a GM ratemeter to assess contamination for compliance wipe tests and exposure rate measurements for daily closeout surveys and patient release measurements for a standard volume ion chamber and a GM ratemeter.

Contamination Assessment:

Removable radioactive contamination assessment is a radioactive materials license condition and must be completed on a weekly basis. Wipe tests are the mechanism to assess removable contamination in the case of veterinary nuclear medicine with unsealed radioactivity. Wipe tests are conducted by wiping an area with a dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of a known efficiency for the isotope in question. Typically, a radioactive materials licensee will wipe test an area of 100 cm^2 or 300 cm^2 dependent on their own internal procedures. The units for wipe tests are disintegrations per minute per unit area (dpm/cm^2)

Empirical data using a Ludlum model 3 ratemeter and 44-9 GM probe show the efficiency for ^{117m}Sn detection to be approximately 20% under 2D geometry. With a background rate of 100 counts per minute (cpm), this radiation detection system has a minimum detectable activity (MDA) of approximately 400 dpm. The standard regulatory threshold for removable contamination of a beta and or gamma emitting radionuclide, such as ^{117m}Sn, in an unrestricted area is 1000 dpm/100 cm^2 [1]. ^{117m}Sn has 159 keV gamma and several low energy conversion electron outputs. Note, the same probe geometry is used in the Ludlum 44-88 and Ludlum 26-1 Dose meter.

The empirical data can be readily recreated in a lab setting using:

1. Liquid Scintillation Analyzer (LSA)
2. Calibrated Pipettes
3. Known concentration of isotope (mCi/mL)
4. Cardboard Paper
5. Paraffin paper

The known activity concentration of the ^{117m}Sn is pipetted into an acceptable concentration to be added to an LSA vial – typically less than 1M counts. Then, the now diluted concentration is used to pipette into LSA vials to establish a known activity from the dilution. Once the known activity is established, the same volume is pipetted onto a dimpled paraffin paper to simulate removable contamination in a standard geometry. The GM probe (44-9) connected to the Ludlum model 3 ratemeter is then used to establish an efficiency. The 20% efficiency quoted above was established with triplicate measurements for both the LSA activity establishment and the paraffin paper standards.

The MDA was established with the below data:

1. Time of the sample count: T_{s+b} = 0.367min on the slow setting for the Ludlum 3
2. Time of the background count: T_b = 0.367min on the slow setting for the Ludlum 3
3. Confidence interval: k = 1.645 for 95% confidence
4. Efficiency: eff = 20% for ^{117m}Sn
5. Background rate: R_b = 100 cpm
6. Lower critical level: L_c = 38.4 cpm — $L_c = k[((R_b/ T_{s+b})+(R_b/ T_b))]^{0.5}$
7. Lower limit of detection: L_d = 84.1 cpm — $L_d = (k^2/ T_{s+b})+2L_c$
8. Minimum Detectable Activity/Wipe: MDA = 422.4 cpm — $MDA = L_d/eff$

Since the minimum detectable activity is much less than the contamination limit for an uncontrolled area, the Ludlum model 3 ratemeter with 44-9 or 44-88 GM probe combination (or other comparable instrument such as the Ludlum 26-1 Dose) is an adequate instrument to measure removable contamination for ^{117m}Sn.

Note, ^{117m}Sn has a similar gamma emission as the commonly used medical radioisotope ^{99m}Tc along with several low energy conversion electron emissions which only aid in the detection efficiency of contamination.

Exposure Rate Measurements:

Radioactive materials licenses require daily closeout surveys of all areas where unsealed radioactive material is used. Further, license conditions require that release exposure rate measurements be completed prior to releasing animals who have been administered unsealed radioactivity. The below information provides guidance to radioactive materials licensees for instrument selection for daily closeout survey and release exposure rate measurements [2][3][4].

Daily closeout surveys are completed by surveying all areas of unsealed radioactive materials use. The goal of the daily closeout survey is to determine if exposure rate license conditions are met. Typically, uncontrolled areas have an exposure rate limit of 0.2 milliRoentgen per hour (mR/h) and controlled areas (such as the Hot Lab) will have an exposure rate limit of 5 mR/h. Daily closeouts help identify contamination, if radioactive waste is appropriately contained, and if sealed sources are properly stored. These surveys can be completed with either a standard volume ion chamber such as the Ludlum 9DP and Victoreen 451P, or they can be completed with an appropriate Ludlum ratemeter and GM probe (44-88, 44-9, or Ludlum 26-1 Dose). The GM option is more practical as this detection instrument can also be used for contamination assessment. Using the same instrument routinely allows for the user to have familiarity with the radiation detector and its properties.

Each animal treated with ^{117m}Sn is required to have a release exposure rate measurement prior to leaving the licensed facility. Most license conditions require the measurement taken not exceed 0.5 mR/h at 1 meter from the treatment site as the mechanism to validate that public dose requirements are met [5]. While the ion chamber is the gold standard for exposure rate measurements, the Ludlum 26-1 Dose with energy flattening filter is more practical. Exposure rate measurement data was compiled with multiple instruments over multiple distances with different activities. The unshielded gamma exposure constant of 0.169 mR m^2 h^{-1} mCi^{-1} was used as the benchmark for expectation values [6]. The ionization chamber response tends to slightly under respond while the Ludlum 26-1 Dose with energy flattening filter tends to slight over respond from theoretical values. Since each instrument is very close to the expectation values, either would be sufficient to use without the need to correct for energy response.

The Ludlum 26-1 Dose without the energy flattening filter can be used for contamination assessment and daily closeout surveys. The Ludlum 26-1 Dose with the energy flattening filter can be used for Synovetin OA release measurements. Therefore the Ludlum 26-1 Dose is the recommended radiation detector for licensees using ^{117m}Sn.

References:

1. 10 CFR Part 835 Appendix D. Surface Contamination Values in dpm/100 cm^2
2. NUREG 1556 Vol 7 Appendix O.
3. Smith and Stabin, Exposure Rate Constants and Lead Shielding Values for over 1,100 Radionuclides, Health Physics Society. https://www.doseinfo-radar.com/Exposure_Rate_Constants_and_Lead_Shielding_Values%204.pdf