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Radiological Self-Absorption: A Study of Analysis Methods

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1. INTRODUCTION

Radiological safety is important. To ensure radiological safety in the work place, many controls have been implemented to limit exposure to dispersible radioactive material. According to the regulatory document 10 CFR 835, the release of uranium contaminated material is based on surface alpha activity levels being less than 1,000 dpm/100 cm^2. However, determining compliance with the regulative presupposes an understanding of measurement modifying factors such as efficiency and the effects of self-absorption. This paper focuses on determining the impact of self-absorption on the measured result. Careful consideration must be given to self-absorption, especially when making decisions about workplace controls and determining the suitability for clearance of items. In principle, the analysis of air sample filters could likewise be affected. Self- absorption affects the true counting efficiency of alpha emitting radionuclides and to a lesser extent, beta emitters (especially metal and metal oxide particulate due to their high densities.) The mission of this study is to determine which gross counting method is most accurate, so that we may account for the phenomena of self-absorption and ensure safety in the work place.

Exposure to radiation is a safety concern that extends beyond the work place [2,3]. The public is exposed to radionuclides, like depleted uranium, in very common places including:

- Vaseline glass and Fiestaware (for color)
- False teeth (to simulate fluorescence)
- Tank armor (shielding)
- Ballasts of commercial airplanes

There have been various studies that detail the merits of reducing unnecessary radiation exposure [1], which has laid the foundation for our study. This experiment offers valuable information regarding the accuracy of instrumentation used to measure activity, including:

- Gas-less Alpha/Beta Counters
- Liquid Scintillation Counters (LSC)
- Gas Flow Proportional Counters (GPC)
- Alpha/Beta Zinc-Sulfide Scintillators
- Single-Chamber Alpha/Beta Sample Counter

2. PROCESS

For this study, fifty one (51) swipes were collected from Depleted Uranium ballast used in commercial aircraft. The swipes widely varied in activity, ranging from approximately 3,000 to 120,000 dpm total Uranium, based on gamma spectroscopy. All fifty one (51) swipes were then counted by GPC, Alpha/Beta Zinc-Sulfide Scintillator and Single-Chamber Alpha/Beta Sample Counter.

Next, the swipes were split into 2 groups:

Group 1: Gas-less Alpha/Beta Counter population

- Comprised of 26 swipes
- Activity measured by Gas-less Alpha/Beta Counter

Group 2: Liquid Scintillation Counter population

- Comprised of 25 swipes
- Activity counted by Liquid Scintillation Counter
- All swipes placed in 20 ml individual vials containing LSC cocktail before being measured for activity

After all of the swipes were measured by these gross counting methods, their beta to alpha ratios were recorded to estimate the impact of self-absorption. Based on the radioactive equilibrium and branching ratios, the beta to alpha ratio for Depleted Uranium should be 1.2:1 to 1.7:1, depending on the level of depletion.

3. INTERIM DATA EVALUATION

The data shows significant underestimated activity relative to the gamma spectroscopy values.

1. Alpha

There was very poor correlation between the methods for alpha quantification. LSC yielded the lowest values and GPC yielded the highest out all the gross counting methodologies.

2. Beta

There was variable correlation between methods for beta. GPC and Gas-less Alpha/Beta Counter appear similar but significantly lower than other methods, which were, themselves, similar. Overall for beta, GPC had the lowest values while LSC had the highest values out of all the gross counting methodologies.

3. Ratios

The beta/alpha ratios were all greater than the expected 1:1.2 to 1:1.7, ranging from 2 to 49 (see Figure 1).

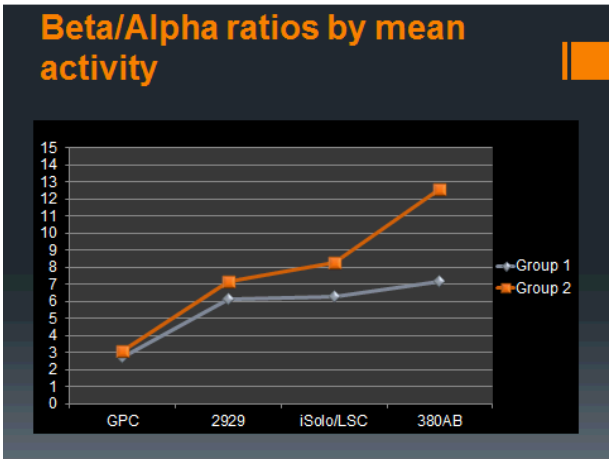
4. PATH FORWARD

Based on the poor correlations and elevated beta/alpha ratios, it's clear that self-absorption is affecting the gross counting data thus far collected. It is unclear which, if any of the gross counting methods provides an accurate indicator of true activity.

Our next step is to develop absorption/attenuation curves using a known Depleted Uranium standard and variable quantities of dissolved solids to create a range of density thickness. These will be counted by the various methods to evaluate the differential effect.

In addition, the swipes collected and discussed above will be split into two sub groups: Group 1a and Group 1b. Group 1a will undergo alpha spectroscopy and Group 1b will undergo mass spectroscopy. Our belief is spectroscopy will identify if any of the gross counting methods provide reliable results, and if none are valid, then we will either evaluate the possibility of using a correction factor or consider other approaches for making accurate determinations of activity based on gross counting analyses.

Figure 1. The beta to alpha ratio, by mean activity, for each gross counting method is compared by group.



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