MONTE CARLO SIMULATION STUDY OF HOT-PARTICLE DETECTION IN VOLUMINOUS SAMPLES BY GAMMA SPECTROMETRY

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In this presentation, we discuss an inhomogeneity problem in gamma spectrometry caused by hot particles, which are dispersed into environment from large nuclear reactor accidents such as Chernobyl and Fukushima. Gamma spectrometry is a well-established method for non-destructive detection of gamma emitters in voluminous environmental and food samples. Radioactive contaminants in a form of refractory hot particles can commonly deposit on food, crops, and soil in the environment. This leads to an issue for gamma spectroscopic analysis since germanium gamma detectors are normally calibrated for bulk samples assuming uniform distribution of radioactivity in them. In many cases, mechanical mixing of environmental soil or food samples does not provide effective homogenization, only repositioning of hot particles in the samples. In this work, we have determined the response of a gamma spectrometer to individual and grouped identical hot particles randomly distributed in a soil matrix of 1-L and 0.6-L sample containers using Monte Carlo simulations. By analyzing the simulation results in detail, we have discovered that the peak-to-total ratio of efficiencies in gamma spectrometry is an excellent empirical parameter to correlate the efficiency and hot particle distributions [1]. We have derived and verified a power-law relationship between the peak efficiency and peak-to-total ratio. This enabled creation of a calibration model which was demonstrated to reduce the bias range and bias standard deviation, caused by measuring hot particles, by a factor of 2-6.5 dependent on cases. The model is independent of the number, location, and distribution of hot particles in the samples. In this work, we have demonstrated successful performance of the model for a single-peak ^{137}Cs radionuclide. The extension to multi-peak radionuclide will also be discussed.

[1]. L. T. Chu, A. G. Burn, C. J. Bradt, T. M. Semkow, 'Monte Carlo Simulation Study of Hot-Particle Detection in Voluminous Samples by Gamma Spectrometry', *J. Appl. Math. Phys*. **2021,** *9*, 1522-1540**.**