Development of an Improved Assay for the Determination of Gross Alpha and Beta Concentrations in Soil by Liquid Scintillation Counting

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We present here a continuation of our ongoing research that was presented at the 42nd Annual Conference on Bioassay, Analytical, and Environmental Radiochemistry; San Francisco, October 13-17, 1996. The U.S. Department of Energy (DOE) has about 4000 sites covering many thousands of acres that are contaminated with radioactive materials. DOE Order 5400.5 documents the requirements and guidelines for the cleanup of residual radioactive materials. In order to characterize residual concentrations of radionuclides in soil for the purpose of identifying if property is suitable for release, gross alpha and beta screening analyses are important for determining whether the applicable regulatory requirements and guidelines are being met. These requirements are usually based on dose limits, control guidelines for radioactive waste and residues, and authorized limits for allowable levels of residual radioactive material.

Unfortunately, the current methods used to analyze soil for alpha and beta activity are considered by many professionals in the environmental monitoring field as being unreliable and ambiguous for numerous reasons. The primary objective of our research is to develop analytical methods for the reliable determination of gross alpha and beta activities in soil samples. We chose liquid scintillation (LS) technology with pulse shape discrimination (PSD) because of its hiegh efficiency and improved alpha/beta separation. Ideally, a method based on LS should provide results that can be confidently used as a basis for decisions involving environmental characterizations and/or the need for additional analyses. There are now environmentally friendly cocktails available for sample analyses that minimize the amount of hazardous waste generated in laboratories.

This research has focused largely on the effects that sample quench has on both the percent misclassification of alpha radioactivity as beta and beta activity as alpha. Additionally, the quench effects on alpha and beta counting efficiencies have been examined. An optimum discriminator setting was identified initially using standards in the low end of the quench range of typical soil samples. Keeping this optimal discriminator setting constant, a series of alpha and beta standards quenched with nitromethane were analyzed on a Packard 2550 TR/AB in order to develop predictable relationships for quench vs. percent misclassification (Figs. 1 and 2) and quench vs. detection efficiencies for alpha and beta activity (Figs. 3 and 4).

Current efforts include using actual soil digests as a quenching agent to identify and quantify any changes in the misclassification and efficiency quench curves that were based on nitromethane. Initial results indicate that adjustments to the percent misclassification and percent efficiency curves will provide more accurate analytical results for the quantification of gross alpha and beta concentrations in soil.

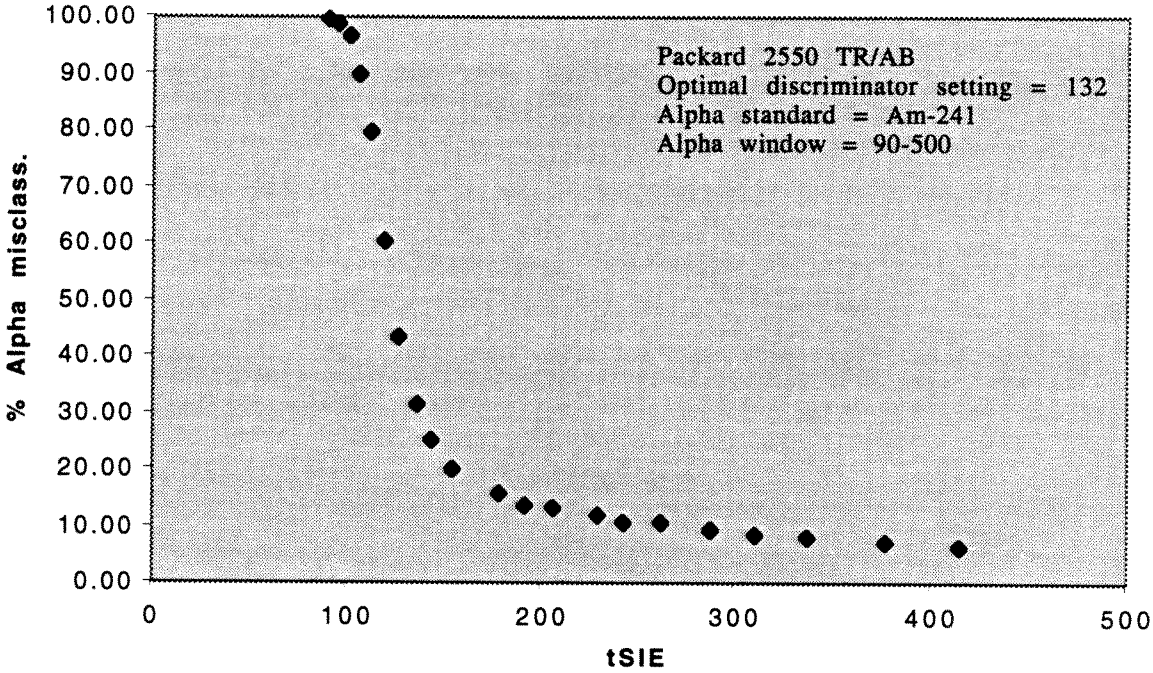

Figure 1 Plot of percent misclassification (alpha to beta) vs. the sample quench (tSIE). Nitromethane was used as the quenching agent and was added in increasing volumes to cause increasing quench. A known amount of Am-241 was added to each quenched standard and counted on the Packard 2550 TR/AB. As quench increased (tSIE decreased), the misclassification increased as well. Note the sharp increase in misclassification at tSIE ~ 150. Because alpha particles are monoenergetic, at a specific level of quench, a significant number of alpha pulses are being misclassified as a whole as betas.

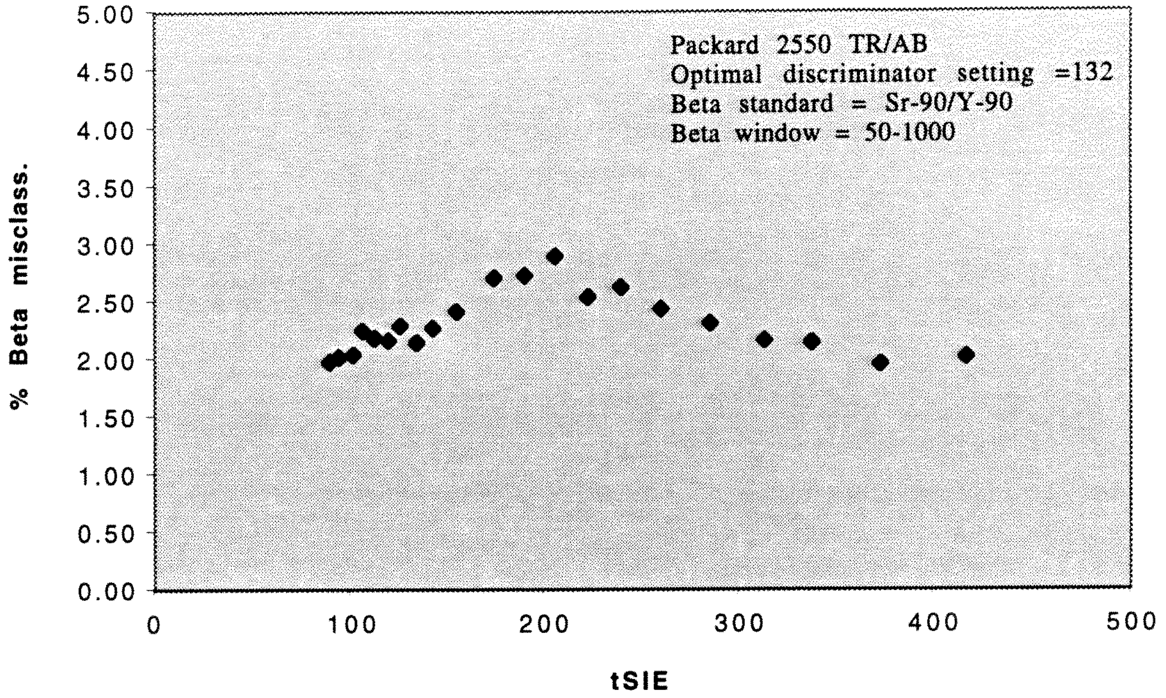

Figure 2 Plot of percent misclassification (beta to alpha) vs. the sample quench (tSIE). A known amount of Sr-90/Y-90 was added to each quenched standard and counted on the Packard 2550 TR/AB. As quench increased (tSIE decreased), the misclassification increased slightly and then decreased. With higher quench, high energy betas pulses that were initially misclassified as alphas pulses above the alpha window (90-500) fell into the alpha window. Then as quench increased even more, these alpha pulses fell below the low end of the alpha window (90) and were most likely not detected by the instrument.

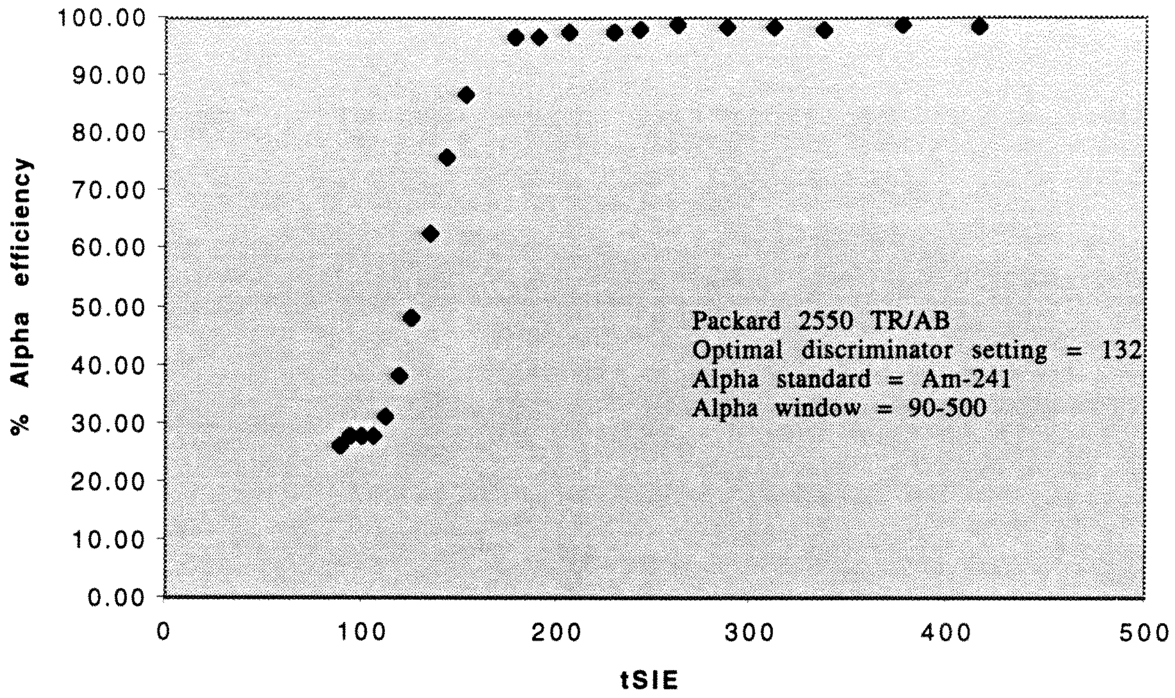

Figure 3 Plot of percent alpha efficiency vs. the sample quench (tSIE). A known amount of pure Am-241 was added to each quenched standard and counted on the Packard 2550 TR/AB. As quench increased (tSIE decreased), the efficiency decreased as well. Note the sharp decreased in alpha efficiency at tSIE < 200. Because alpha particles are monoenergetic, at a certain level of quench, a majority of the alpha pulses are not being detected by the instrument.

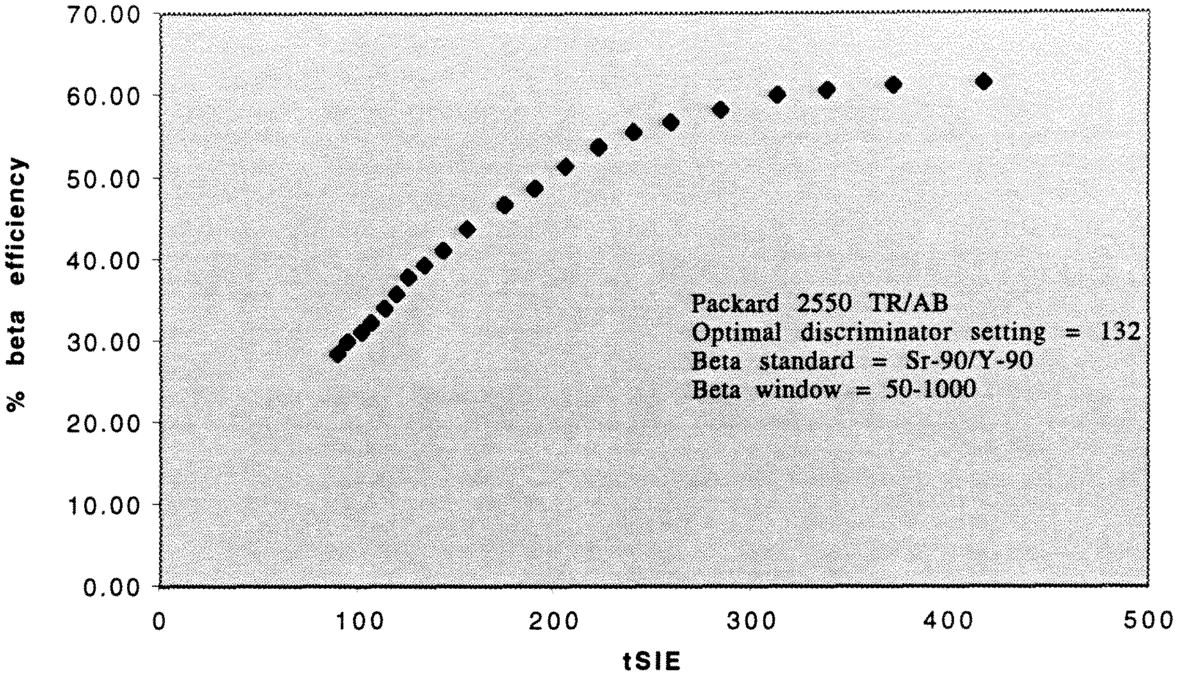

Figure 4 Plot of percent beta efficiency vs. the sample quench (tSIE). A known amount of Sr-90/Y-90 was added to each quenched standard and counted on the Packard 2550 TR/AB. As quench increased (tSIE decreased), the efficiency decreased as well. Note the gradual decrease in beta efficiency over the range of tSIE. Because beta particles are not monoenergetic, as quench increases, the higher energy betas will be detected by the instrument while the lower energy betas fall below the window setting and are not detected.