CONF-811103--54

AN ALPHA-BETA-GAMMA SPECTROMETER AS AN AID IN DIRECTING DECONTAMINATION OF SOILS

C. D. Berger

MGW

To be presented at the American Nuclear Society winter meeting, November 29 - December 4, 1981, San Francisco, California.

AN ALPHA-BETA-GAMMA SPECTROMETER FOR DIRECTING DECONTAMINATION OF SOILS*

C. D. Berger
Industrial Safety & Applied Health Physics
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37830

One of the primary goals of environmental surveillance programs for decontamination and decommissioning of nuclear facilities is to obtain information essential to assessing and controlling dose rates to neighboring populations. This objective also includes identifying the type of specific contaminants for the purpose of predicting trends in radiation levels. Experience has shown, however, that environmental radionuclide concentrations are so variable that contamination boundaries, particularly hot spots of alpha or beta activity, could be missed in the presence of a high gamma background by other than the most sensitive detection devices.

The FIDLER probe,[1] a thin inorganic scintillator of NaI(Tl) that absorbs photons preferentially up to a desired maximum energy, has been used for detection of internal conversion L x-rays and brehmsstrahlung in soils, but Compton scattering of high-energy gamma rays in the crystal or the sample produces a low-energy response that must be treated as competing background. A ZnS scintillator that has a low detection limit due to the negligible interaction of gamma rays with the crystal has been adapted for field assessment of alpha contaminants in soil[2] but it is a count rate device, rather than a spectrometer, and gives no beta or gamma information. Oak Ridge National Laboratory has adapted a detector for potential use as

---

*Operated by Union Carbide Corporation under Contract W-7405-eng-26 with the U. S. Department of Energy.

a survey instrument, because it has a lower minimum detectable activity for alpha and beta emitters than the FIDLER, plus performs as an alpha-beta-gamma spectrometer to determine the quality of radiations in the soil, as well as the quantity.

Equipment Description

The detector probe is an optical "sandwich" of two phosphors, called a phoswich. This concept has been used for some time in low background counting of low-energy photons.[3] A 0.20-mm-thick CaF_2(Eu) scintillator has been optically coupled to a 2.54-cm-thick NaI(Tl) guard scintillator. Radiation events in each can be distinguished due to their different light decay times. Operation of the CaF_2(Eu) in anticoincidence with the NaI(Tl) reduces its background by a factor of two because of Compton suppression and because the NaI(Tl) is an active shield. By using pulse-shaping electronics, as shown in Figure 1, alpha and beta spectra from an environmental sample are obtained from the CaF_2(Eu), and the gamma spectrum from the NaI(Tl)

To prevent passage of energetic betas into the NaI(Tl) a 3-mm-thick quartz dead layer is interposed between the two scintillators. Since the CaF_2(Eu) layer is very thin, the beta spectrum is compressed to low pulse height, resulting in approximately 95% separation of beta and alpha events. Separation is even greater when operating in a windowless mode.

Analysis Procedure

Soil samples (20 gm) are placed in a petrie dish to insure repeatable geometry, and the detector probe is placed directly on top of the soil. Ribs on the probe provide a consistent 1.1 mm spacing between the face of the probe and the sample. Routine count time is 10 minutes.

Energy calibration is performed with an electroplated ^{239}Pu source, a ^{90}Sr source, and a ^{137}Cs source. Since the current application of this system is detection and quantification of ^{239}Pu in soils containing ^{137}Cs, ^{90}Sr and naturally-occurring background radionuclides, a 20 gm sample of soil was evenly "spiked" with ^{239}Pu to provide a calibration of counts per minute per pCi ^{239}Pu per gram of soil. An uncontaminated soil sample from the type of soil being measured is used to determine the natural alpha, as well as beta-gamma, background.

Results

Alpha detection limits for a 10-minute count time as a function of background are 35.8 pCi ^{239}Pu/g of soil at the 1σ level, and 71.6 pCi/g at the 2σ level. Results of alpha-beta-gamma analysis of soil samples from the Nevada Test Site were compared with radiochemistry results from the same samples. Agreement was noted within a factor of 2.3 for ^{239}Pu, ^{137}Cs and ^{90}Sr.

Conclusion

This technique permits rapid assessment of alpha-beta-gamma-emitter contamination in soils at sufficiently low concentrations to direct field operations. Of particular importance is its applicability during initial decommissioning and decontamination surveys when characterization of alpha and beta contamination in the presence of a high gamma background is necessary. This system has not yet been made portable for in-situ use, but it is expected that results will be favorable when operated as a field instrument, resulting in simplified standard decontamination operation.

Figure 1. Block Diagram of Alpha-Beta-Gamma Spectrometer Electronics.

REFERENCES

1. J. F. Tinney, and J. J. Koch, Lawrence Livermore Laboratory Progress Report UCRL-50007-67-3, 6 (1967).

2. A. J. Ahlquist, C. J. Umbarger and A. K. Stoker, Health Physics 34 (1978).

3. R. Laurer and M. Eisenbud, "Diagnosis and Treatment of Deposited Radionuclides," Symposium Proceedings, Richland, Washington, May 1967.

ORNL-DWG 81-5430