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Instrument efficiency variations with different probe areal phoswich detectors for simultaneous alpha/beta detection

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In decommissioning, the radiological characterization of potentially contaminated sites is required to estimate the residual activity. Prior to actual samplings for the analysis, scanning survey with a movable radiation detector enables to measure the contaminated sites quickly and find local areas with elevated activity. For the scanning survey, minimum detectable concentration (MDC) of a field survey instrument is an important factor to reliably measure radiation particles and verify whether the contaminated sites exceed residual radioactivity criteria. The MDC is mainly calculated by parameters such as probe area, background count rate, instrument efficiency influenced by source-to-detector distance and source-to-detector geometry, surface efficiency, and dwell time. The probe area is highly correlated with the variables of instrument efficiency and background count rate. In this research, as an initial step of calculating the MDC depending on probe areas, phosphor sandwich (Phoswich) detectors for simultaneous alpha and beta detection were manufactured to identify the variations of instrument efficiency and background count rate with the probe areas of 10×10 cmˆ2, 15×15 cmˆ2, and 20×20 cmˆ2. Instrument calibration for each probe area was conducted with the calibrated radioactive sources of 15×10 cmˆ2 areal Am-241 for alpha measurements; and 10×10 cmˆ2 areal SrY-90, Tc-99, and C-14 for beta measurements. Since the dimensions of a contaminated area can not be known a priori, it was assumed that instrument efficiencies calibrated from distributed sources are used for all surface activity measurements during scanning survey. In this principle, the same probe areal radioactive sources are ideally required for instrument calibration. To demonstrate the source-to-detector geometry of the same probe areal radioactive sources by using a limited size of the sources, new calibration approach was proposed based on Monte Carlo N-Particle Transport Code (MCNP) 6.2 simulation results. To enhance light collection efficiency and consequently increase instrument efficiency by coupling an optimal light guide, commercially available optical design software lighttools was used for light transport simulation. Experimental data showed that instrument efficiency decreased when probe area increased. On the contrary, background count rate tended to increase, especially for beta measurements. In the case of alpha measurements, background count rate did not exceed 2 cpm.

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