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Optimizing Scintillator Thickness and GEB Parameters for Beta Spectroscopy in Plastic Scintillation Detectors

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One of the radiation monitoring systems in nuclear power plants, the condenser air removal system continuously evaluates the amount of fission products leaked from the primary to the secondary system by measuring the β-ray emitted from inert gases. During a leakage event, the major β-emitting nuclides in inert gases include ^{133}Xe, ^{85}Kr, ^{85m}Kr, ^{135}Xe, ^{137}Xe, ^{41}Ar, ^{88}Kr, and ^{87}Kr. To evaluate the leakage rate, it is essential to determine the specific radioactivity concentration (μCi/cc) of β-emitting nuclides and the detection efficiency (cpm/μCi/cc). While the radioactivity concentration of β-emitting nuclides can be readily obtained through sampling and gamma spectroscopic analysis of the primary coolant, determining the detection efficiency is more challenging. This is because the efficiency calculation involves complex computational processes. Additionally, the values provided by system manufacturers are typically limited to only one or two radionuclides, restricting the accuracy of the leakage rate evaluation. If energy spectrum analysis from β-rays, similar to gamma spectroscopy, were possible, real time leakage rate evaluation would become significantly more feasible without the need for preliminary work or complex calculations.
Accurately measuring the β-energy spectrum is essential for beta spectroscopy, and one of the key factors influencing this process is the thickness of the scintillator. If the scintillator is too thin, β-ray energy may not be fully transmitted, making it difficult to obtain the complete energy spectrum. Conversely, if it is too thick, the detection efficiency for γ-rays increases, which can interfere with β-ray measurement. Thus, optimizing the scintillator thickness is crucial for accurate beta spectroscopy.
In this study, as a preliminary investigation for beta spectroscopy, we aim to determine the optimal scintillator thickness for β-spectrum measurement. By comparing the MCNP simulated spectrum with the actual detector spectrum, we seek to derive the appropriate thickness that maximizes measurement accuracy. Additionally, we apply Gaussian Energy Broadening (GEB) to the simulated spectrum to accurately describe the detector response function and extract the GEB parameters (a, b, c). The results show that the simulated spectrum, generated using the optimized scintillator thickness and GEB parameters (a, b, c) derived from the genetic algorithm, closely matches the measured detector spectrum.

Workshop topics

Applications

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