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Feasibility Study on the Development of an Integrated Fast neutron and Gamma ray Radiography System for Material Decomposition

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Radiography is utilized in various industries and medical fields as one of the Non-destructive Testing methods, enabling the acquisition of intrinsic information about materials by penetrating them with radiation. Particularly, by employing methods such as dual-energy X-ray radiography or X-ray combined neutron radiography, it is possible to discern different materials based on the differences in their attenuation coefficient ratios. In this study, a dual particle radiography system was developed using the organic plastic scintillator EJ276G and the SiPM model Hamamatsu S13360-6025CS. Material phantoms including PVC, Aluminium, Acrylic, Lead, Copper, Brass, Teflon, and Stainless steel were utilized, with a Cf-252 source (76.2 μCi) for fast neutron imaging and a Cs-137 source (75.5 μCi) for gamma-ray imaging. After obtaining the neutron and gamma-ray intensities for the eight substances mentioned above, the intensities in air were log-transformed to calculate Σt and μt values for each substance. Afterward, the attenuation coefficient ratio between fast neutrons and gamma rays was defined to obtain the R-value for each material. The effective atomic number (Zeff) ranged from 6.47 (acrylic) to 82 (lead) with R values ranging from 0.37 to 5.23. Through this, the feasibility of classifying various materials from a homeland security perspective was confirmed. Future studies will collect time of flight (TOF) data from radiography systems to determine detector response functions. Subsequently, we will use Monte Carlo simulations to tabulate the R-values of various effective atomic numbers.

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