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Design of a Radioluminescence Dosimetry System with Photon Energy Discrimination Capability for Area Monitoring

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Area monitoring, including environmental and workplace radiation surveillance, is essential in settings with significant radiation exposure such as nuclear reactors, accelerator facilities, contaminated waste sites, and NORM-affected zones in the oil and gas industry. Photon energies in these environments typically range from 20–30 keV to several MeV, requiring dosimetry systems whose response accounts for energy dependence. This study explores the feasibility of using a real-time radioluminescence (RL) fiber dosimetry system designed to correct for energy-dependent detector response via photon energy discrimination. The system comprises multiple RL sensors with varying filtration layers, each coupled to transmission fibers. The primary scintillator is a 2 cm long, 1 mm diameter cerium-doped silica fiber, selected for its high sensitivity and well-characterized energy-dependent behaviour. Monte Carlo simulations using the TOPAS/Geant4 code were conducted to model the RL sensors and design filter combinations for energy correction, following ISO 4037 recommendations. The Low Air Kerma Rate Series was used as the reference photon spectra, and dosimeter responses were evaluated relative to the 137Cs reference energy. Simulation results suggest that an optimized combination of filtered RL elements can support photon energy estimation and correction of dosimeter response, enabling improved accuracy in the calculation of ambient dose equivalent, H*(10). The proposed real-time RL dosimetry system offers potential for enhanced dose assessment in workplace monitoring, contributing to improved radiation protection and operational safety.

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