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Development and Applications of a New Deuterium-Deuterium (D-D) Neutron Generator

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A new deuterium-deuterium (D-D) neutron generator has been developed for non-destructive neutron inspection techniques. The neutron generator is composed of three major components: An RF-Induction Ion Source, the Secondary Electron Shroud, and the Diode Accelerator Structure and Target. The generator produces monoenergetic neutrons (2.5 MeV) with a yield of 1010n/s using 25-50 mA of beam current and 125 kV of acceleration voltage. Three nuclear analytical techniques were tested and optimized to be used with the neutron generator: (1) Prompt γ -ray neutron activation analysis (PGNAA) of 10B concentrations in Si and SiO₂ matrices was carried out using a germanium detector (HPGe) and the results obtained are compared with a PGNAA system using a NaI detector. (2) The radiography facility used in the measurements and simulations employs a fully high-voltage-shielded, D-D neutron generator. Both fast and thermal neutron images were acquired with the generator and a Charge Coupled Devices camera. To shorten the imaging time and decrease the noise from gamma radiation, various collimator designs were proposed and simulated using MCNPX. Design considerations included the choice of material, thickness, position and aperture for the collimator. (3) Optimization of a D-D neutron generator based explosive detection system (EDS) was performed using Monte-Carlo simulation. The shape and the thickness of the moderators and shields are optimised to produce the highest thermal neutron flux at explosive position and the minimum total dose at the outer surfaces of the explosive detection system walls. In addition simulation of the response functions of NaI, BGO, and LaBr₃-based γ -ray detectors to pure chemical elements is described.

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