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Feasibility Study and Experiment of On-Site Nuclear Material Identification in Fukushima Daiichi Fuel Debris by Compact Neutron Source

Authors : Yudhitya Kusumawati, Yuki Mitsuya, Tomooki Shiba, Mitsuru Uesaka

Abstract : After the Fukushima Daiichi nuclear power reactor incident, there are a lot of unaccountable nuclear fuel debris in the reactor core area, which is subject to safeguard and criticality safety. Before the actual precise analysis is performed, preliminary on-site screening and mapping of nuclear debris activity need to be performed to provide a reliable data on the nuclear debris mass-extraction planning. Through a collaboration project with Japan Atomic Energy Agency, an on-site nuclear debris screening system by using dual energy X-Ray inspection and neutron energy resonance analysis has been established. By using the compact and mobile pulsed neutron source constructed from 3.95 MeV X-Band electron linac, coupled with Tungsten as electron-to-photon converter and Beryllium as a photon-to-neutron converter, short-distance neutron Time of Flight measurement can be performed. Experiment result shows this system can measure neutron energy spectrum up to 100 eV range with only 2.5 meters Time of Flightpath in regards to the X-Band accelerator's short pulse. With this, on-site neutron Time of Flight measurement can be used to identify the nuclear debris isotope contents through Neutron Resonance Transmission Analysis (NRTA). Some preliminary NRTA experiments have been done with Tungsten sample as dummy nuclear debris material, which isotopes Tungsten-186 has close energy absorption value with Uranium-238 (15 eV). The results obtained shows that this system can detect energy absorption in the resonance neutron area within 1-100 eV. It can also detect multiple elements in a material at once with the experiment using a combined sample of Indium, Tantalum, and silver makes it feasible to identify debris containing mixed material. This compact neutron Time of Flight measurement system is a great complementary for dual energy X-Ray Computed Tomography (CT) method that can identify atomic number quantitatively but with 1-mm spatial resolution and high error bar. The combination of these two measurement methods will able to perform on-site nuclear debris screening at Fukushima Daiichi reactor core area, providing the data for nuclear debris activity mapping.

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