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Development of a Prompt Gamma-ray Neutron Activation Analysis System for the detection of explosive materials

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Unlike x-ray imaging which can display images according to the degree of absorption of x-rays by the objects, neutron activation analysis can be used for the detection of explosives because it can be used for determining the presence of unknown elements in the objects. Also, since neutrons are able to penetrate through some heavy metals and they significantly interact with some light and organic materials, it can be used for the baggage scanner in airport. In neutron activation analysis, neutrons can convert stable atomic nuclei into radioactive nuclei and make it emit gamma-rays according to the elemental composition. Therefore, to design a neutron activation analysis system for the detection of explosive materials, we determined a neutron source, neutron collimator, a transport system, a gamma-ray detector, a sealed shielding box made of lead and high hydrogen content shielding around the detectors.

As a neutron source, the deuterium-tritium(D-T) neutron generator was determined that emits 2.5e+09 n/s with 14.1 MeV. Also, neutron collimator made of high hydrogen content shielding with 2 centi-meters of slit was designed to expose fan beam shaped neutrons to the luggage. Also, a transport system was designed to adjust the inspection speed. In addition, as a gamma-ray detector, CdZnTe semiconductor type detector were determined after the consideration into its energy resolution and high atomic number. To mitigate the unintended neutron activation, we designed a sealed shielding box made of 10 centi-meter thickness of lead and 10 centi-meter thickness of polyethylene shielding around the detectors. As a result, we acquired the gamma-ray spectroscopy induced by fast neutrons and calculated the atomic ratios of carbon to oxygen and nitrogen to oxygen to detect the explosive materials.

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