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Neutron-Dose Control of First Responders Under Sampling and Categorization

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Nuclear forensics are the technical means by which nuclear and other radioactive materials used in illegal activities are characterized as to composition, physical condition, age, provenance, and history(1),(2). Nuclear forensics process consists of 3 steps; sampling, categorization, and characterization. Sampling is to collect nuclear materials or post-explosion debris for a radiological and nuclear incident such as a dirty bomb or a radiological dispersal device (RDD). The samples are used for the characterization at laboratory measurements. The categorization of nuclear materials to a significant degree by measurements from portable instruments on-site are required. Nuclear materials and RDDs, which makes criticality field, emit neutrons whose energy range can vary from thermal to several MeV. In particular, the fast neutrons around over 1MeV have a strong damage for human body. Portable equipment and radiation protection for radiological emergency response team to achieve emergency tasks safely at the incident sites have been developed and evaluated in National Research Institute of Police Science (JAPAN). In this report, we introduce fast neutron shield with water under sampling and categorization. The thickness of water shield in developed prototype equipment is 10cm, which decrease to 1/3 fast neutrons and 1/2 gamma-rays (Co-60). The neutron shield is mounted on an electric cart with DC mortar, which maximum speed is 3km/h. A long tong is set to the center of shield, with which first responders can collect samples safely.

Described next in this report are evaluation tests of real-time personal dosimeters using low-scatter room (neutron irradiation field) in Pacific Northwest National Laboratory. We evaluated them under fast neutron field and thermal neutron field. Tested were real-time personal neutron dosimeters of different types, PDM-313 (Hitachi Aloka Medical, Japan), ADM-353 (Hitachi Aloka Medical, Japan), EPD-N2 (Thermo Scientific, USA), DMC2000GN (MIRION Technologies, France), NRF31 (Fuji Electric, Japan), and NRG13 (Fuji Electric, Japan). These devices are all based on semiconductor detectors. They consist of a single or two Si diode with converters (Li-6 or B-10), makes use of the nuclear reaction. They have digital displays of dose, and a warning function using light, sound and/or vibration. The dosimeters were attached on a 40×40×15cm3 phantom and located at the distances of 30cm, 55cm and 100cm from the neutron sources (Am-Be, bare Cf-252, and moderated Cf-252), respectively. The dose rates were 0.866mSv/h, 3.41mSv/h and 3.68mSv/h, respectively. We decided irradiation time in which the accumulated doses were set to about 0.5mSv. We compared the response for each dosimeters under direct irradiation and irradiation with neutron shield (10cm thickness polyethylene corresponded to water). A 10cm-tickness shield was set 10cm in front of the dosimeters. The neutron spectrum with neutron shield was thermalized to lower energy, which intermediate neutrons increased. Under thermal neutron field (moderated Cf-252 source), responses of Aloka dosimeters were 2-4 times higher than those of other dosimeters. We can see same situation in the past results (at criticality field (3), around a spent fuel cask(4), EVIDOS Project (5)). However the significant difference of each dosimeter's responses was not confirmed under moderated Cf-252 source with neutron shield. Under Cf-252 irradiation which mean energy is 2.3MeV, doses of Aloka and Thermo dosimeters are lower than those of Fuji and MIRION dosimeters, whereas the opposite tendency for Am-Be irradiation which mean energy is 4.4MeV. This is owe to the difference of calibration source (Cf-252 or Am-Be) for each dosimeters at factory setting. The difference is consistent with the past result(6), which we lead to the correct dose using the correction factor for neutron energy. Also we confirmed the effect of fast neutron shield and the large fluctuation of the response for each dosimeter owe to thermalized neutron field.

(Reference)

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Country and/or Institution

JAPAN, National Research Institute of Police Science

Primary author: Dr TSUCHIYA, K. (Japan)

Co-authors: Dr SCHWANTES, J. (Pacific Northwest National Laboratory, USA); Mr RICHARD, P. (Pacific Northwest National Laboratory, USA); Mr ROMAN, P. (Pacific Northwest National Laboratory, USA)

Presenter: Dr TSUCHIYA, K. (Japan)

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