Neutron-Dose Control of First Responders under Sampling and Categorization

K. Tsuchiya *[1], J. M. Schwantes *[2], R. M. Pierson *[2], R. K. Piper *[2]
[1]Physics Section, National Research Institute of Police Science (NRIPS), Kashiwa, Chiba, Japan
[2]Pacific Northwest National Laboratory (PNNL), Wa, USA
tsuchiya@nrips.go.jp

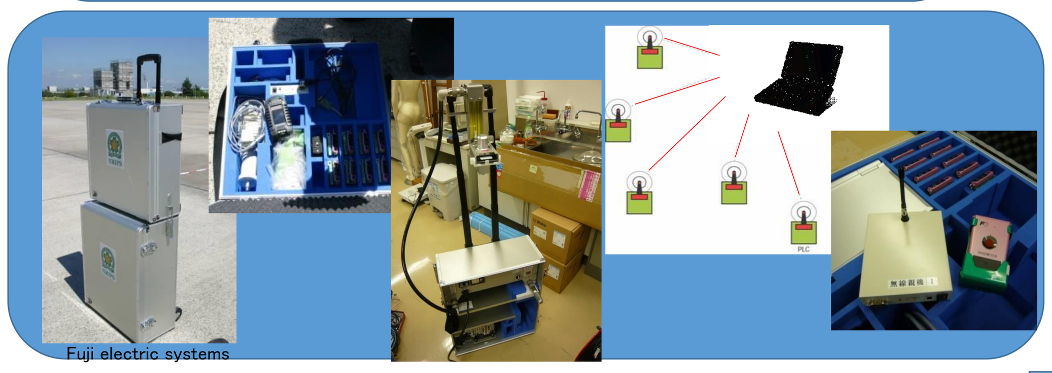
Abstract

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 (NRIPS, JAPAN). In this report, we introduce fast neutron shield with water and wireless network personal dosimeters under sampling and categorization. Described next in this report are evaluation tests of real-time neutron dosimeters using low-scatter room (neutron irradiation field) in Pacific Northwest National Laboratory. We evaluated them under fast neutron field and thermal neutron field.

1. Development of neutron shield and neutron dose monitoring system

Neutron shield with water

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.



10 wireless network personal dosimeters

- Real time monitor system for personal dose with wireless network in the field.
- Maximum range : 100m at open space

3 handheld devices Radioisotope identification, neutron detection, high-dose rate and contamination check

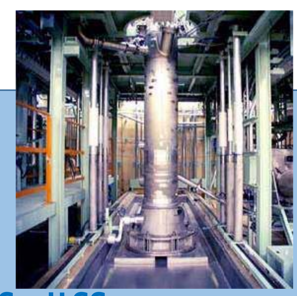
Air sampling : 50ℓ/min at 1m height

2. Past evaluation of personal dosimeters

SILENE 2002 [1]
Nuclear criticality field

This reactor allows the simulation of various criticality accidents, pulse mode, free evolution and steady state. 71% of personal dosimeters are within ± 25 % of reference dose value.

TRACY(JAEA)-NRIPS 2010 [2]
Nuclear criticality field



Tested are real-time personal neutron dosimeters of different types, NRG13 (Fuji Electric Systems, Japan), ADM-353(Aloka, Japan) and DMC2000GN (MGP, USA). These solid state dosimeters have digital displays of dose, and a warning function using light, sound and/or vibration. The dosimeters were attached on a 30*30*15cm^3 phantom, and located at the distances of 1.35m and 5.5m from the TRACY core. The dosimeters at 1.35m were irradiated directly (bare condition). On the other hand, a 30cm-tickness water shield was set in front of the dosimeters at 5.5m (water shield condition). The dose indicated by ADM-353 was 2 times by NRG13 in bare condition, whereas the dose indicated by ADM-353 was over 8 times by NRG13 in water shield condition(Figure.1). They are caused by the energy responses of dosimeters and variation of neutron spectra at the location.

Irradiation (1) Bare

Irradiation (2) Water shield (Displays on dosimeters were observed with a CCD camera)

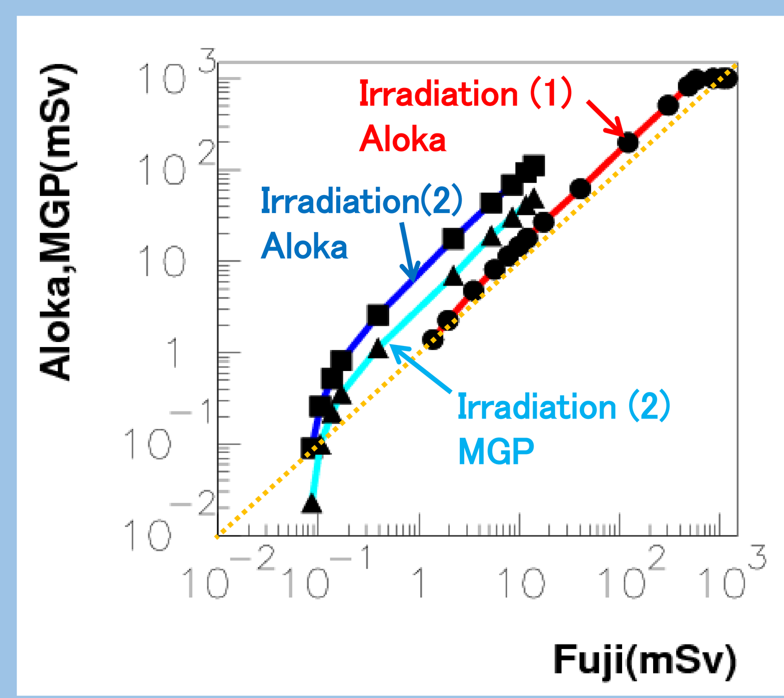


Fig.1 Comparisons between dose indicated by each dosimeters[2]. Aloka and MGP for Fuji Electric Systems

Passive Dosimetry → Active Dosimetry

3. Evaluation of neutron dosimeters

The dosimeters were attached on a 40×40×15cm^3 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.

	Aloka PDM313	Aloka ADM353	Thermo EPD N2	MGP(MIRION) DMC2000GN	Fuji NRF31	Fuji NRG13
Detector type	Neutron	Neutron/ gamma	Neutron/ gamma	Neutron/ gamma	Neutron/ gamma	Neutron/ gamma
Resolution	10uSv	100uSv	1uSv	10uSv	1uSv	100uSv
Dose range	10uSv-100mSv	100uSv-1000mSv	1uSv-16Sv	10uSv-10Sv	1uSv-10Sv	300uSv-1000mSv
Size (mm)		110*52*18	86*63*19	87*48*31	60*78*27	
Weight (g)		90	108	80	<100	
# of dos.	#1,#2	#3,#4	#5-#7	#8-#10	#11-#13	#14

Table.1 Tested neutron dosimeters

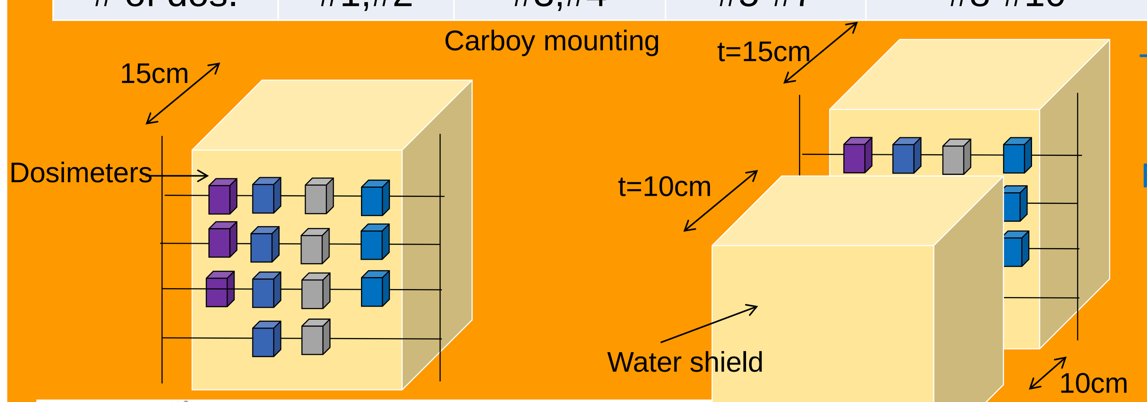


Fig.2 Schematic view of evaluation geometry

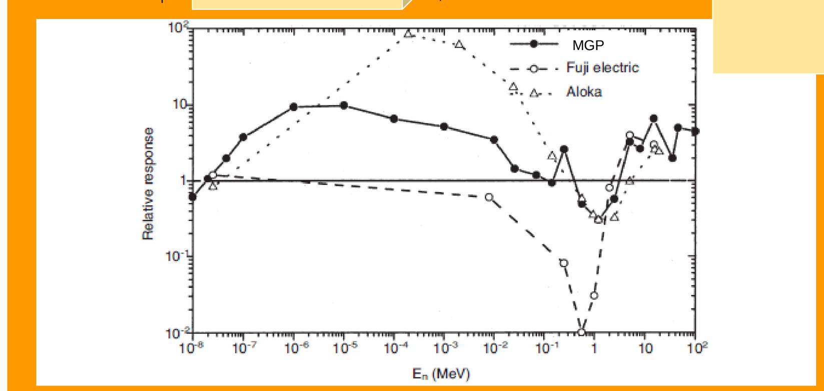


Fig.3 Relative dose equivalent response for normally incident neutrons as a function of neutron energy[3].

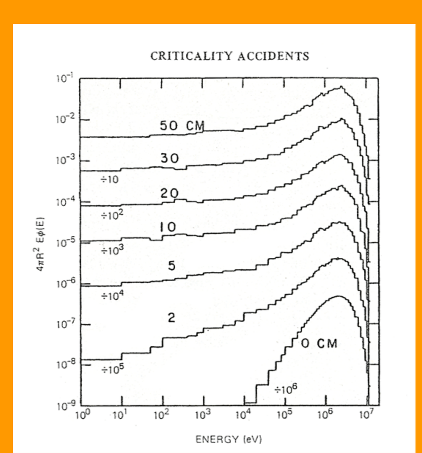


Fig.4 Neutron spectra penetrated in water.
[IAEA Tec. Rep. Ser. No.211(1982)]

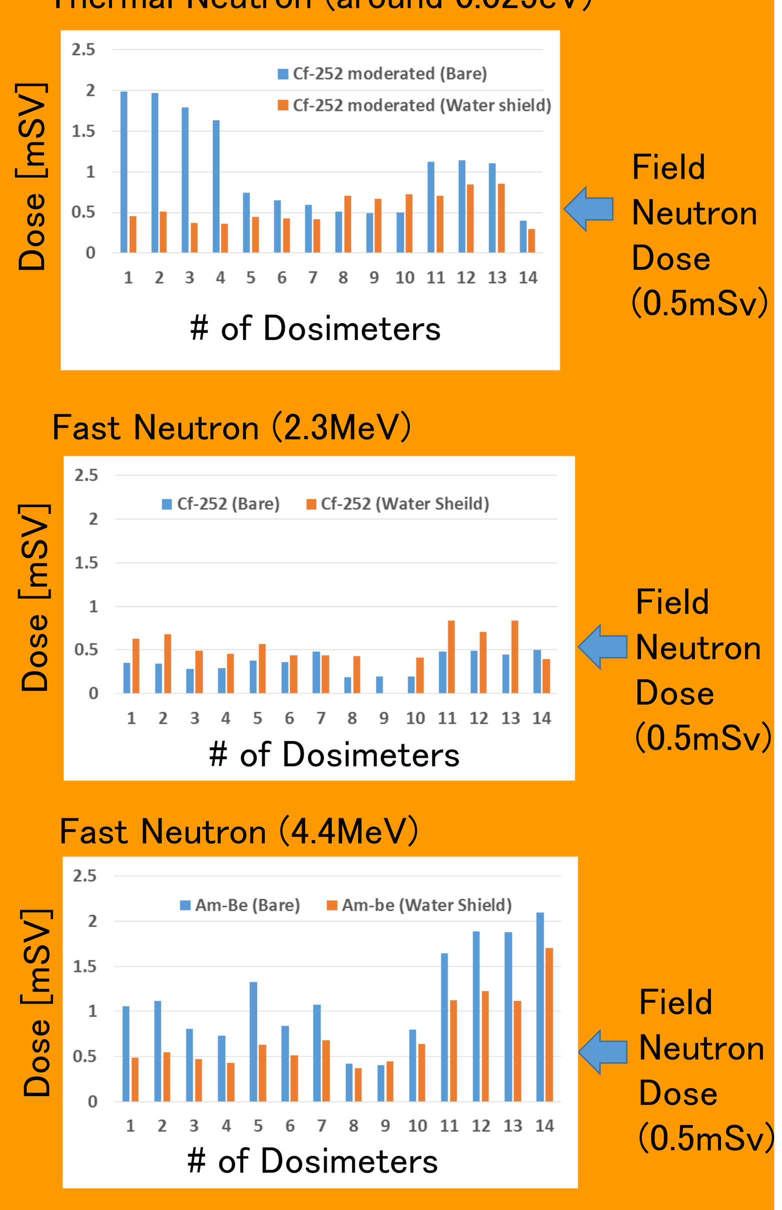


Fig.5 Response of different neutron Dosimeters.

4. Results and Summary

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[2], 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 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.

[Reference]
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