CO10-1 Activation Analysis for Soils of Hiroshima･Nagasaki City and Gamma-ray Exposure Due to Neutron-induced Radionuclides by Atom Bomb

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INTRODUCTION: For early entrance survivors in Hiroshima and Nagasaki atomic bomb (A-bomb), radiation doses from activated materials induced by the A-bomb neutrons are dominant. For estimation of such doses, element compositions of environmental materials such as soil and rubbles are necessary. Especially Sc density in soil is important for estimating radiation doses at the time of a few 10 days after explosion because ^{46}Sc has the half-life of 84 days. However, few data of Sc density in soil are available in both of Hiroshima and Nagasaki cities. Purpose of this study is evaluation of Sc density in soil and the uncertainty using activation analysis.

EXPERIMENTS: Soil samples were taken from 11 locations within 5 km from A-bomb hypocenter at Nagasaki city. The soil samples were dried by an oven at 120 degrees for an over-night. The dried samples were sieved through a 2-mm mesh to remove pebbles and plant remains. The sieved samples of about 10 g were grained to fine mesh by a mortar for activation analysis. The soil samples and reference rock sample of JA-1and JB-1[1]were activated in Kyoto University Reactor (KUR). Element compositions of soil samples were obtained by comparing counting rates of each identified radionuclide by Ge-detectors with those from reference rocks.

RESULTS: Twenty six element compositions including Al, Mn, Na and Sc are obtained by the activation analysis as listed in Table 1. The obtained element compositions are compared with values used in Dosimetric System 1986 (DS86) [2] and found roughly the same as the reported values in DS86. Mn and Sc density in Nagasaki soil was estimated to be 1570±632 (ppm) and 19.5±3.01 (ppm), respectively. These values are relatively higher than 517±67 (ppm) and 5.12±0.59 (ppm) of Hiroshima soil [3], respectively. It was found the unevenness of Sc density in soils for 11 location of Nagasaki City is about 15%. This results shows that the Sc contribution for dose in air at a few 10 days after explosion at Nagasaki City is relatively higher than those at Hiroshima City.

REFERENCES:

[1] Imai, N.*et al*. (1995) 1994 compilation of analytical data for minor and trace elements in seventeen GSJ geochemical reference samples, "igneous rock series", Geostandards Newsletter 19: 135-213.

[2] Roesch, W. C., Eds. (1986) U. S.—Japan Joint Reassessment of Atomic Bomb Radiation Dosimetry in Hiroshima and Nagasaki. Vols. 1 and 2. Radiation Effects Research Foundation.

[3] S. Endo et al. (2013) Neutron activation analysis for soils of Hiroshima City and Plaster under roof-tiles of Old Hiroshima House, Revisit the Hiroshima A-bomb with a Database Vol. 2, Hiroshima City 2013, ISBN: 978-4-9905935-1-3,9-14

Table 1. Averaged values of element concentration in soil and DS86 for Nagasaki City [1].

Element	concentration（ppm）			DS86Values（ppm）	
				Hypocenter	Nagasaki Univ.
Na	6120	±	4020	7890	7500
Mg	13700	±	3120	8200	7350
Al	95500	±	22000	99600	97000
K	6320	±	3620	7640	7540
Sc	19.5	±	3.0	20	20
Ti	6040	±	2040	5860	6320
V	190	±	56	167	171
Cr	178	±	84	151	152
Mn	1570	±	632	1310	1260
Fe	59000	±	10900	57300	58800
Co	26.1	±	7.5	23	22
Ni	55.4	±	26.3	53	54
Rb	29.4	±	15.9	70	68
Sr	178	±	61	134	124
Zr	234	±	76	126	127
In	0.054	±	0.017	-	-
Cs	2.69	±	0.80	4.0	4.0
Ce	34.6	±	8.1	43	43
Sm	4.9	±	1.8	3.9	4.0
Eu	0.75	±	0.21	1.5	1.6
Gd	5.12	±	1.31	-	-
Dy	3.73	±	1.51	-	-
Yb	2.11	±	0.61	-	-
Hf	5.3	±	0.74	6.0	6.1
Ta	0.91	±	0.23	0.6	0.5
Th	6.3	±	1.2	7.0	7.2

採択課題番号 24006　広島・長崎原爆中性子による誘導放射能評価のための組成分析　　共同通常
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CO10-2 Damage of Semiconductor Equipment by Radiation Exposure

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INTRODUCTION: Quantitative evaluation of the radiation effect on the semiconductor equipment is important in estimating the damage of the nuclear disasters and planning how to defense the damage [1]. Our group has been working on evaluating this radiation effect [2]. In 2012, the radiation damage to condenser-resistor (CR) circuit was investigated.

EXPERIMENTS: The irradiation was performed with Kyoto University Research Reactor Institute Heavy Water Neutron Irradiation Facility (KUR-HWNIF), at a power of 1 MW. The utilized mode was the standard mix neutron irradiation mode (OO-0000-F). As semiconductor equipment, digital timers (A&D corporation, AD-5712GR) were utilized. The digital timers were placed at varied distances of 0, 20, 50, 100, and 190 cm from the collimator aperture as shown in Figure 1. At each distance, two digital times were arranged. Irradiation was performed for 62 minutes.

Fig. 1. View of irradiation port

RESULTS: Table 1 shows the dose irradiated. The values correspond to the dose to human tissue. At distances of 50 cm or more, the times worked correctly, while the USB memories were out of order at similar doses [2]. The times at 20 cm (331 mGy at the dose rate of 320 mGy/h) had a problem, i.e., each of them was 40 seconds and 180 seconds ahead of correct time, respectively. On the other hand, at 0 cm (646 mGy/h at 667 mGy), one timer was 1000 seconds ahead, the other did not show any characters. The latter could not be restarted or reset after the irradiation, while the others worked correctly.

Assuming the threshold for the timer to have a problem to be 173 mGy, the dose at 50 cm, exhibited value ahead of the correct time was 40 and 180 seconds at the excess dose of 158 mGy (20 cm), and 1000 seconds at the excess dose of 494 mGy (0 cm). The correlation between both values can not be concluded so far.

Table 1. Absorbed dose by irradiation

Distance to collimator aperture (cm)	Dose (mGy)		
	Thermal neutron	Epithermal neutron	Fast neutron
0	1.28×10^{2}	1.38×10^{1}	2.30×10^{2}
20	5.75×10^{1}	6.48	9.40×10^{1}
50	2.56×10^{1}	3.01	2.68×10^{1}
100	9.93	1.17	3.32
190	2.25	2.18×10^{-1}	4.99×10^{-2}

Table 1. (*cont.*)

Distance to collimator aperture (cm)	Dose (mGy)	
	Gamma rays	Total
0	2.96×10^{2}	6.67×10^{2}
20	1.73×10^{2}	3.31×10^{2}
50	1.17×10^{2}	1.73×10^{2}
100	7.74×10^{1}	9.18×10^{1}
190	2.41×10^{1}	2.66×10^{1}

SUMMARY: The digital times irradiated showed abnormal operation at doses of 331 mGy or more (neutron contributions at 30 to 35 %). The exhibited time ahead of the correct time and the irradiated dose have not been concluded as to their relationship. However, the frequency and amount of abnormality possibly works as an index of the exposure to human body in nuclear disaster.

REFERENCES:

[1] J. Takada, Nuclear hazards in the world, Kodansha (Tokyo) and Splinger (Berlin), (2005) 1-133.
[2] K. Tanaka, Y. Sakurai, J.Takada, Radiation Protection Medicine, **8** (2012) 47-50.

採択課題番号 24078　　核放射線照射による電子機器の誤作動の検証　　共同通常
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CO10-3 Study on Neutron Response of Criticality Accident Alarm System Detector to Quasi-Monoenergetic 24 keV Neutrons

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INTRODUCTION: A criticality accident alarm system (CAAS) is a purpose-built radiation monitor intended to provide an immediate evacuation signal in the case of an accidental criticality in order to minimize personnel exposure. The latest model of the CAAS, recently developed and installed at the Tokai Reprocessing Plant of the Japan Atomic Energy Agency, consists of a plastic scintillator combined with a cadmium-lined polyethylene moderator and responds both to gamma rays and neutrons [1]. To evaluate the detector response to 24 keV quasi-monoenergetic neutrons, an experiment was performed at the B-1 facility of the Kyoto University Research Reactor.

EXPERIMENTS: The B-1 facility consists of 45-cm-thick iron and 35-cm-thick aluminum filters built in a radial beam tube of the reactor and provides an intense beam of 24 keV neutrons transmitted through 'resonance window' in the cross-sections of iron and aluminum [2]. The 10 cm × 10 cm square opening at the beam exit is smaller than the dimension of the CAAS detector; therefore, a wooden platform attached to the motion mechanism of a motor-driven linear actuator was constructed and the CAAS detector mounted on the platform was horizontally moved across the neutron beam along the line perpendicular to the beam axis and 100 cm distant from the beam exit. A neutron rem counter (Studsvik 2202D) and an energy-compensated GM counter (FWT GM-1), each spaced 60 cm and 30 cm from the CAAS detector, were also mounted on the platform and irradiated simultaneously to evaluate the reference dose rates of neutron and gamma ray, respectively. The neutron response of the CAAS detector was derived by dividing the neutron-induced net reading, deduced by subtraction of the estimated gamma-ray fractional reading based on the gamma dose rate, by the reference neutron dose rate. The reactor was operated at 1 MW.

RESULTS: Fig. 1 compares readings of the CAAS detector, the 2202D, and the GM-1 as a function of the traverse distance from the beam center (0 cm). Full travel was 60 cm: 0 to +60 cm for the CAAS, −30 to +30 cm for the GM-1, and −60 to 0 cm for the 2202D. The curve measured with a physically small GM tube represents the actual dose profile, showing that the entire neutron-sensitive region (i.e., moderator) of the CAAS detector was covered with the neutron beam over half the peak intensity.
Fig. 2 exhibits the energy dependence of the relative neutron absorbed dose rate response of the CAAS detector. The experimental data obtained in this study is plotted together with the data obtained with a ^{252}Cf neutron source [3]. Also plotted are the computer–calculated responses for monoenergetic neutrons. A comparison showed that experimental data at 24 keV reasonably agreed with those obtained with previous calculations. The agreement between the experimental and calculated responses gave strong experimental support to the calculated response functions over the entire energy range from thermal to a few MeV.

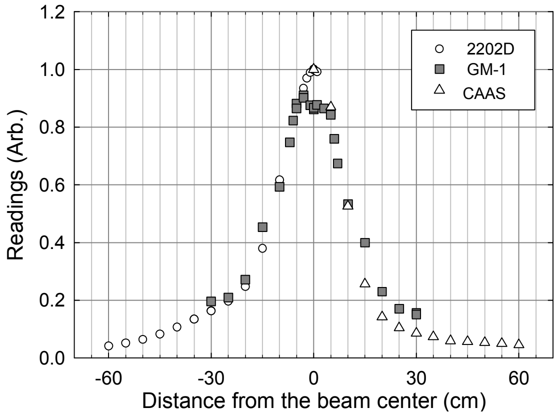

Fig. 1. Readings of the CAAS detector, the 2202D, and the GM-1 across the neutron beam, scanned along the line perpendicular to the beam axis and 100 cm distant from the beam exit.

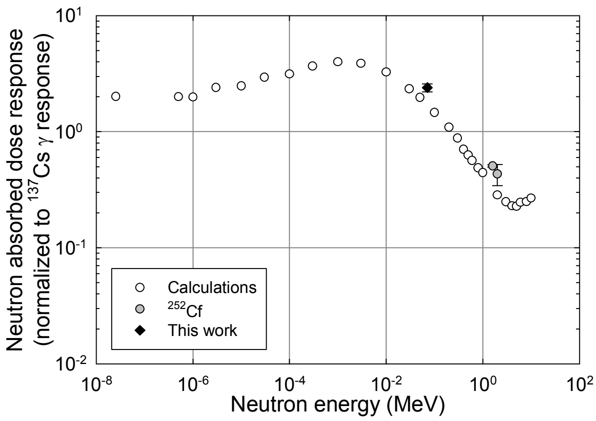

Fig. 2. Neutron absorbed dose rate response of the CAAS detector as a function of the neutron energy.

REFERENCES:

[1] N. Tsujimura and T. Yoshida, Prog. Nucl. Sci. Technol., **1** (2011) 202-205.
[2] K. Kobayashi, T. Yoshimoto, Y. Fujita, M. Utsuro, and H. Utsumi, *Reactor Dosimetry: Radiation Metrology and Assessment*, ASTM STP 1398 (2001) 183-190.
[3] N. Tsujimura and T. Yoshida, Prog. Nucl. Sci. Technol. (in press).

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（原子力機構）辻村憲雄，吉田忠義（京大・原子炉）八島浩