

Experiments on dosimeter response to photon exposure for nuclear industry workers with glass badge, electronic personal dosimeter or optically stimulated luminescence dosimeter in use

ガラスバッジ、電子線量計または OSL 線量計を使用した
原子力産業従事者の光子被ばくに対する線量計レスポンス試験

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Background: Japanese nuclear workers cohort study has been conducted since 1990 and analyzed radiation risk in association with $H_p(10)$. However, evaluation of risks using organ absorbed dose is recommended. In addition, data from the National Cancer Registry became usable. The most comprehensive preceding study on reconstructing organ dose was the Study of Errors in Dosimetry under the framework of the IARC 15-Country Collaborative Study, which conducted experiments on dosimeter response to photon exposure for three types of dosimeter used before 1990s. These data were useful for the Japanese study but not sufficient. Usage of dosimeters in Japan developed from those to glass badge (GB), electronic personal dosimeter (EPD) or optically stimulated luminescence (OSL) dosimeter in around 2000.

Aim: To describe the experiments on dosimeter response for GB, EPD and OSL dosimeter.

Materials and Methods: Following the IARC's approach, the experiments on dosimeter response were carried out within the two laboratories of JAEA. X rays of N-150 and N-250, and ^{137}Cs source were used. Three types of dosimeters were selected for the study. To simulate working conditions, combinations of a specific photon energy; 119 keV, 207 keV and 662 keV, and a specific geometry; AP and ISO geometry, were applied for RANDO phantom set up on the horizontally rotating device with an angle between the rotation axis and the source.

Results: Data on dosimeter response to air kerma were calculated along with uncertainty, which were compatible with IARC's data. This work was funded by the Nuclear Regulation Authority, Japan.



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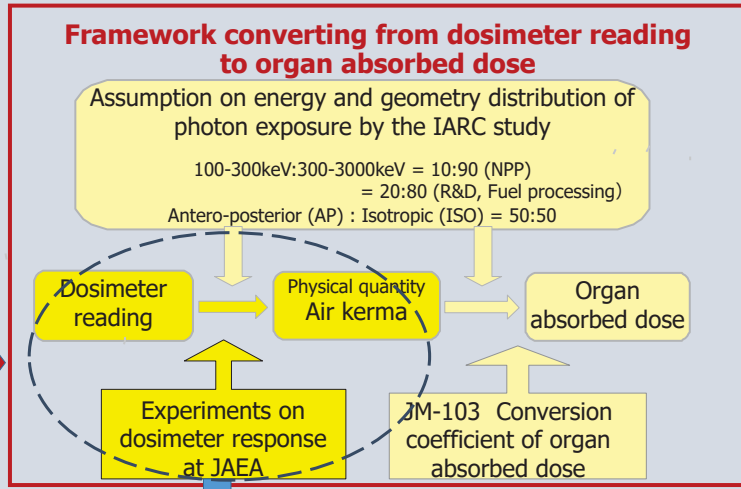
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J-EPIISODE (Japanese Epidemiological Study on Low-Dose Radiation Effects):

A cohort study on health effects for nuclear workers exposed to low dose radiation, excluding medical workers.

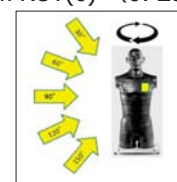
Data essential for analyzing cancer morbidity and mortality risk based on organ absorbed dose

Dose			
Dosimeter reading (1957-)		Radiation Dose Registration Center, REA	
Conversion coefficients from dosimeter reading to organ absorbed dose		REA, Report on reconstruction of organ dose (2019)	Published
End Point			
Cancer mortality	Follow-up of vital status	Resident register	
	Cause of death	Death certificate, Vital Statistics	
Cancer morbidity	First visit data on primary cancer by site	National Cancer Registry (2016-)	Approved to use
Confounder			
Smoking, eating tendency, cancer incident history, CT consultation history, SES, etc.		Life-style survey for all participants (2015-2019)	Completed



Outline of dosimeter response experiments conducted at JAEA calibration laboratories

- Irradiation apparatus:
 - Facility of Radiation Standards (FRS)
 - Source X-rays N250 (Mean energy 207keV) and N150 (119keV)
 - Instrument Calibration Facility (ICF)
 - Source ¹³⁷Cs gamma-rays (662keV)
- Type of personal dosimeter: Glass badge (GB), Electronic personal dosimeter (EPD) and optically stimulated luminescence dosimeter (Luminess badge [LB])
- Dosimeter calibration test on the slab phantom
- Acquisition of dosimeter response data under a specific combination of energy and geometry on the RANDO phantom, as the next;
 - Dosimeter reading / Air kerma (Sv/Gy)
 - Energy : 119, 207, 662 keV
 - Geometry : AP
 - ISO ← Estimated from ROT(θ) (θ : Zenith angle)



Device to rotate RANDO phantom Simulation of isotropic irradiation

Dosimeter response experiments conducted by the IARC study:

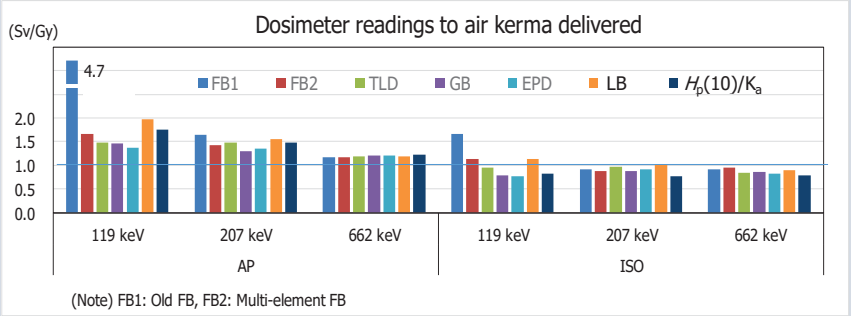
- ✓ Covered type of dosimeter used during 1940 to 2000.
- ✓ Old type film badge (FB1), Multi-element FB (FB2) and thermoluminescence dosimeter (TLD)
- ⇒ These results were referred in the present study.

Dosimeter response experiments conducted in the present study:

- ✓ Covered type of dosimeter used in Japan after 2000 in order to complement the IARC data.
- ✓ GB, EPD and LB

Results :

- Greater variation among dosimeter types at low energy, but within allowable limits, except old film badge (FB1).
- Lower response in ISO than that in AP, because of attenuation due to shoulders and pelvis.
- Small differences among dosimeter types, except FB1.



Conclusions:

- Dosimeter response data in working condition are indispensable for reconstruction of organ absorbed dose.
- Experiments for GB, EPD and LB intended to complement the lack of coverage of dosimeter type in the IARC study.
- The obtained data for dosimeter types recently used in Japan are consistent with those of FB2 and TLD in the IARC study.
- The obtained data are used for reconstructing organ absorbed dose in J-EPIISODE.
- The obtained data are usable for other cohort studies on nuclear workers.

References :

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- I. Thierry-Chef, et al. The 15-country collaborative study of cancer risk among radiation workers in the nuclear industry: Study of errors in dosimetry. Radiat. Res. (2007)
- H. Furuta, et al. Dosimeter response to photon exposure of electronic personal dosimeters, radio photoluminescent glass dosimeters, and optically stimulated luminescence dosimeters used by nuclear workers in Japan. Radiat. Prot. Dosim. (Submitted)
- REA, Report of the committee on reconstruction of organ dose for J-EPIISODE, March 2019
- This study was funded by the Nuclear Regulation Authority.