CN9501670

Application of Radiophotoluminescence Dosemeters for Environmental Monitoring

A. Mihara, Y. Ohi*, T. Tamura, T. Mochizuki, T. Numakunai and Y. Yoshida
Institute of Radiation Measurements, Tokai-mura Ibaraki-ken, 319-11, Japan
*Japan Atomic Energy Research Institute, Tokai-mura Ibaraki-ken, 319-11, Japan

ABSTRACT

Feasibility study has been made on the radiofluorescence glass (RPL) dosemeters for environmental radiation monitoring. Main items in the laboratory tests are batch uniformities of pre-dose and sensitivity, build-up characteristics of RPL intensity, energy and angular responses, stabilities for RPL reading, anneal cycling and climatic conditional changes. We have determined self-irradiation dose and cosmic ray contribution. Radiation monitoring field test for the RPL dosemeters has been conducted in comparison with the present TLD systems. A procedure manual for the environmental monitoring by the use of RPL dosemeters is in preparation.

INTRODUCTION

Over the years, thermoluminescence dosemeters (TLD) have been used for environmental radiation monitoring with unique features: high sensitivity, good temporal integration, low fading, and passive mechanism providing wider coverage of monitoring area with moderate cost. In the TLD system there still remain inconsistencies as were observed in the international intercomparison[1]. Further improvements in the reliability and precision seem desirable from the view point of tendency of reduced dose limits for the public. Recently, radiophotoluminescence dosemeter (RPLD) have been receiving a particular attention as a very promising integral dosemeter by the adoption of a narrow UV laser exitation with flat glass detectors and automatic readout systems. Present state of art of RPLD are reviewed in ref.[2]. Their salient features are:repeated readout capabilities, excellent batch uniformity in sensitivity, long-term fading stability, thus openning a new possibility for environmental monitoring.

Under the research contract of standardization of radiation protection instruments from Science and Technology Agency, we have been undertaking a feasibility study of RPLD which satisfies the requirements prescribed in the Guides of Environmental Monitoring[3] issued by Nuclear Safety Commission, Japan.

TEST ITEMS AND TEST PROCEDURES

In the application for environmental monitoring, measurement conditions are varied: temperature ranges -20°C to +40°C, radiation dose levels are low, energy and angular distributions are unknown and the integration time usually ranges a few months. Thus emphases of studies and tests were placed on the following items:

1) basic characteristics,
2) field tests,
3) preparation of the procedure manual for the environmetal monitoring.

In the present experiment, RPLD element SC-1 (FD-7) (see Table 1 caption) and reader FGD-20 both supplied by Toshiba Glass Co. Ltd. are used with specified annealing, calibration and readout conditions.[4] Dose calibrations were performed with a precision of 4% in air kerma (Gy) in the Radiation Standard Facility

of Japan Atomic Energy Research Institute. Many tests (referring to ref.5) were performed for a set of 3 to 10 dosemeters in a batch in the same condition and were averaged by the use of a common calibration factor separately obtained for the 10 dosemeters in the same batch. Therefore, test results contain an uncertainty of approximately 4 %.

RESULTS

(1) Basic characteristics of SC-1 RPL dosemeters are examined for the batch uniformities, responses, stabilities, storage and irradiation temperature effects, self-irradiation dose and others. The results are summarized in Table 1. Batch uniformities for pre-dose and sensitivity are excellent and we can use a common calibration factor for all the elements in the batch. Higher sensitivity, good dose lineality, and sensor and reader stabilities are essential factors for the promotion of reliability and precision. Temperature effects for storage and irradiation time are important factors for the environmental monitoring since the dosemeters are usually placed in the field where the climatic conditions are severe. Figs. 1 and 2 show relative RPL intensities for short and long storage time. The completion of build-up of RPL intensities takes 1 hour to several days according to the ambient temperatures. Saturation values also subject to the storage temperatures. At an elevated temperatures, we observe slight fading (decay). For the integration period of 90 days, the fading factor does not exceed 3% at most for the ambient temperature at 40°C. Relationships between irradiation temperature and pre-reading heat treatments are shown in Fig. 3. The results indicate that the 70°C, 1h heat treatment assures 96% to 90% intensity for the very wide irradiation temperature range of -30 to 40°C. For the 90 days integration period, further decrease of this effect can be expected.

(2) Field tests

Self-sheilding effects for various detector configurations are examined at the same monitoring points. Horizontal and vertical orientations do not affect the dose reading. Compact packed dosemeter arrangements gave approximately 6% lower values with 2.5 time larger variation.

Environmental monitoring test was conducted for 3 months at 4 monitoring sites from August to November, 1992. The results are presented in Table 2 in comparison with TLD data obtained concurrently. Evaluated values of 80 to 114 μGy (variational coefficient=0.03 – 0.04) are obtained by subtracting the self-irradiation dose and cosmic ray contribution. Dose values from RPL dosemeters are in good agreement with TLD data.

Through the various tests, we confirmed superiority of RPL dosemeter system in comparison with the present TLD system with respect to batch uniformities, stabilities, reproducibilities, and simplicity of handling. Procedure manual is in preparation to ensure compliance with the Guides for the Environmental Monitoring. Authors would like to thank the Committee members for the Standardization of Radiation Protection Instruments, and Dr. K. Minami, and members of Dep. of Health Physics, JAERI. We acknowledge the sponsorship of this study to Science and Technology Agency.

References:

1) M. L. Maiello et al.: The 8th International Intercomparison of Environmental Dosemeters, Rad. Prot. Dos. 32 No 2 p 91

2) E. Piesch et al.: Photofluorescence Dosimetry: Progress and Present State of Art: Rad. Prot. Dos. 33 No 1/4 p 215 (1990)
3) Nuclear Safety Commission: Guides for Environmental Radiation Monitoring (1989)
4) Toshiba Glass Co. Ltd.: Handling Manual for Photofluorescence Glass Dosemeter Systems for Personal Monitoring and Environmental Monitoring (1992)
5) Japan Industrial Standards: Radiophotoluminescence Glass Dosimeter Systems for X and Gamma Radiation; JIS Z 4314 (under revision)

Table 1 Basic properities of RPL dosemeters
(SC-1: 16×16×1.5 mm, PF-7 : Al:6.1, P:31.5, O:51.2, Na:11.0, Ag:0.17%)

Batch uniformities in	
Pre-dose	: 17.5±0.3 μGy (17.2~17.9 μGy for 10 elements)
Sensitivity	: <1% (100 μGy) 0.6% (500 μGy)
Min. sensitivity	: ~1 μGy
Responses in	
Energy	: 1.2 (80 keV), 1.0 (0.66 MeV), 1.25 (6 MeV)
Angle	: 1.0±0.5 (80 keV except 75°), 1.0±0.15 (0.66 MeV)
Dose linearity	: ±5% (10 μGy), <2% (>100 μGy)
Stabilities in	
Fading	: non det. for 20°C storage for 90 days (see Fig.2)
Reading reproducibility	: no variation for 20 times
Annealing cycle	: no variation for 90 cycles
Reader	: <2% for light, humidity, voltage (100±15%),
Self-irradiation dose	: 23 μGy / 90 days
Temperature effects	: see Figs. 1, 3 and text

Table 2 Results of the RPL dosemeter field test at 4 monitoring points for 3 month period (1992.8 — 1992.11)

Point	Dose evaluated *1 (μGy/90d)		
	TLD(UD-200S)*2	TLD(UD-804IPQ)*2	RPLD(SC-1)*3
MS-2	94.3±3.5	83.8±1.7	88.6±2.8
MS-3	86.4±5.2	79.4±4.4	79.8±3.7
MS-4	118.7±7.0	114.4±3.5	113.6±3.6
MP-13	100.4±5.2	92.5±2.6	93.2±4.3
BG(control)*4	52.4±2.6	51.5±1.7	65.5±2.1

*1 Dose evaluated = Dose(observed) - Dose(BG in control)
*2 Average of dose from 6 elements separately calibrated
*3 Average of dose from 4 elements calibrated by using a common calibration factor determined from 10 dosemeters in the same batch.
*4 BG(control) = Dose observed by the control dosemeters(average of 6 or 4 elements) placed inside the 5cm Pb shield at MS-4

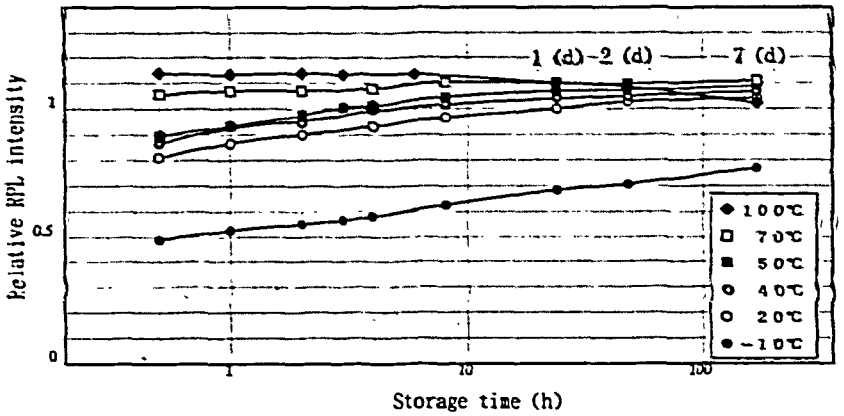

Fig.1 RPL build-up characteristics of RPL dosemeter, SC-1 for various temperatures

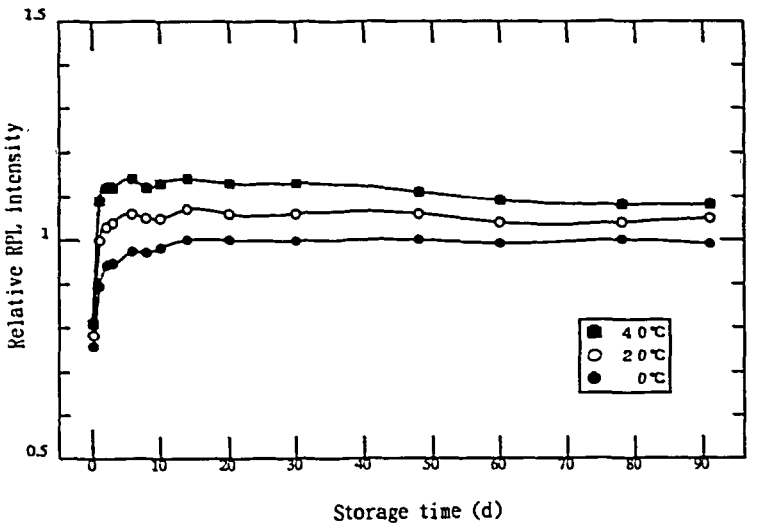

Fig.2 Relative RPL intensity versus storage temperature. No fading tendency was observed for the storage under 20℃ ambient temperature(uncertainty=3%).

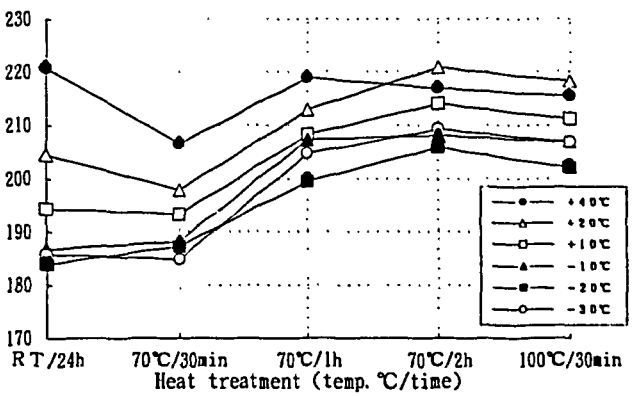

Fig.3 Relative RPL yield under various irradiation temperatures and pre-reading heat treatments.

(1) Saturated RPL yield is achieved for the 40℃ irradiation followed by 70℃/1~2h,100℃/30min,and room temperature /24h.

(2) Nearly saturated RPL yield is achieved for 20℃ irradiation followed by 70℃ /1~2h heat treatments.

(3) 96~90% RPL for lower temperature irradiations followed by heat treatments.