Electronic Personal Dosemeter

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1. Introduction

Since developing an electronic personal dosemeter that uses a semiconductor detector in 1983, Fuji Electric has continued to make improvements and has developed the first electronic personal dosemeter in Japan capable of neutron measurement. Fuji Electric presently holds a 70 % share of the Japanese market for electronic personal dosemeters used for personal dose control in nuclear power plants. Fuji is eyeing future development for overseas nuclear power plants[(2),(3)] and is also moving ahead with development in compliance with Japanese Standard JISZ4312 (2002) "Direct reading personal dose equivalent (rate) meters and monitors for X, γ, β and neutron radiations" and International Standard IEC61526 (1998).

2. Overview and Characteristics

The electronic personal dosemeter is a device carried in a worker's breast pocket that measures and displays in real-time the radiation dose received while working. If the dose exceeds a preset working dose warning level, an alarm is issued and the worker can be notified immediately with a high-frequency sound. Electronic personal dosemeters have continued to be improved, and in recent years, noise-tolerance and shock-resistance characteristics have been enhanced, and reliability has been increased dramatically. When electronic personal dosemeters capable of multi-radia-

Fig.1 Exterior view of electronic personal dosemeter

NRF30021
(γ (X) ray)

NRF40021
(γ (X) ray, noise-tolerant, shock-resistant type)

Fig.2 Radiation characteristics of the electronic personal dosemeter

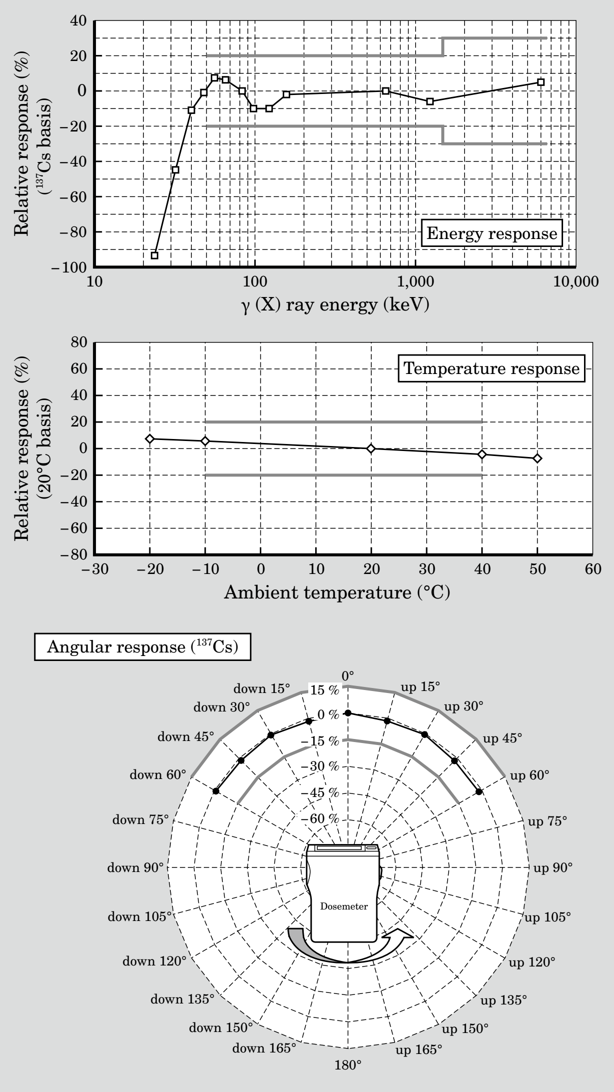


Table 1 Specifications of electronic personal dosemeter (γ (X) ray)

Item \ Model	NRF30021	NRF40021
Radiation detected	γ (X) ray	
Energy range	50 to 6 MeV	
Energy response	Within ±20 % (50 keV to 1.5 MeV), Within ±30 % (1.5 to 6 MeV)	
Angular response	Within ±20 % (up to ±60° in horizontal and vertical directions, ^{137}Cs)	
	Within ±50 % (up to ±60° in horizontal and vertical directions, ^{241}Am)	
	Within ±30 % (360° all around horizontal direction, ^{137}Cs)	
Accuracy (dose)	Within ±10% (0.02 mSv or above)	
Linearity	Within ±10% (0.1 mSvh^{-1} or above)	
Response time	Within 5 s (5 mSvh^{-1} or above)	
Static electric noise	Contact discharge ±8 kV, Gaseous discharge ±15 kV	
Alarm function	Buzzer volume : greater than 85 dB (at 20 cm), greater than 80 dB (at 30 cm), Display lamp: flashing red LED	
Power source	Battery : CR123A, 1 cell, (2,880 hours of continuous use)	
Temperature response	Within ±20 % (−10 to +40°C)	Within ±10 % (−20 to +50°C)
Shock resistance	1.5 m fall (onto wooden panel)	2.0 m fall (onto 20 mm-thick iron panel)
Resistance to electromagnetic noise	100 V/m, 60 A/m, PHS, cell phone contact	100 V/m, 400 A/m, PHS, cell phone contact
Splash-proof	JIS protection class 4	JIS protection class 4, submersion-tolerant, resistant to salt water spray
Case material	Plastic	Magnesium alloy + protective rubber
Mass	Approx. 100 g (including battery, clip)	Approx. 115 g (including battery, clip)
Size	60 (W) × 78 (H) × 27 (D) (mm)	62 (W) × 82 (H) × 27 (D) (mm)

tion measurement in real-time were first developed, external noise often resulted in counting errors, and more precise measurement was needed.

So that external noise does not affect the radiation response of the electronic personal dosemeter, the shielding of the case interior has been improved to provide noise-tolerance characteristics of 100 V/m at 100 kHz to 500 MHz, and 400 V/m at 50 Hz/60 Hz, and to prevent interference from electromagnet noise even if a PHS, cell phone or the like comes into contact with the case. Furthermore, a water-resistant construction enables trouble-free operation even while withstanding water spray at a rate of 10 liters/m for more than 5 minutes. In the past, accidently dropping an electronic personal dosemeter, during it was taken along, could lead to incorrect operation or malfunction, but the internal construction has also been improved so as to enable the dosemeter to withstand a 1.5 m vertical drop onto a hard wood surface in any direction.

Developed as an electronic personal dosemeter having enhanced environmental-resistance, the NRF40021 uses a case made of a magnesium alloy and incorporates shockproof parts so as to be capable of withstanding a 2.0 m vertical drop onto a 20 mm-thick iron plate in any direction, and also features improved noise-tolerance characteristics and is water resistant to a depth of 30 cm for 20 seconds. Figure 1 shows the exterior view of two of Fuji Electric's electronic personal dosemeters.

These dosemeters satisfy the representative radia-

Fig.3 Exterior view of dosemeter reader

tion characteristics for energy response, temperature response and angular response, as specified by JIS and IEC standards (Fig. 2). The energy response and temperature response indicate the energy dependence and temperature dependence of the sensitivity to γ (X) rays, and the dose measurement accuracy is within ±20 % or ±30 % over a wide energy range or a wide temperature range, respectively. Similarly, the measurement accuracy with respect to the angle of incidence of radiation rays is within ±15 %.

Characteristics of the electronic personal dosemeter are listed below. Specifications are also listed in Table 1.

(1) High performance : Compliance with JIS Z4312 (2002) and IEC61526 (1998)
(2) Low power consumption : 1 primary battery cell, usable for 1 year
(3) Anti-static : Contact discharge ±8 kV, gaseous discharge ±15 kV
(4) Moisture resistant : −10 to +40°C, 35 to 95 %
(5) Resistance to electromagnetic waves : 100 V/m
(6) Vertical drop shock resistance : 2.0 m drop, NRF40021
(7) Waterproof : IP64 (IEC60529) compliant
(8) CE marking acquired

Having measured dose data in real-time, the electronic personal dosemeter is easily linked to external data processing equipment via an infrared communication interface to realize a highly functional personal dose control system. In this personal dose control system, data is transmitted from the main device of an electronic personal dosemeter, via a dosemeter reader for data communication (see the external view in Fig. 3), to an upper-level computer server, so as to implement efficient safety control of the workers.

3. Types of Electronic Personal Dosemeters

Electronic personal dosemeters mainly measure γ (X) rays which have a large affect on personal dose control, and are also capable of measuring β-rays and neutrons. Fuji Electric's product line is based on electronic personal dosemeters that measure γ-rays, but also includes units that measure "γ-rays + β-rays" and "γ-rays + neutrons".

Table 2 shows the measurement functions for β-rays and neutrons.

Additionally, an electronic personal dosemeter for use in Japan is capable of measuring three types of radiation simultaneously : γ-rays + β-rays + neutrons. This unit was developed as the world's first 3-type dosemeter, and is currently being utilized in nuclear power plants in Japan. In particular, the ability to measure neutrons distinguishes our electronic personal dosemeter from those made by other companies.

4. Accessories

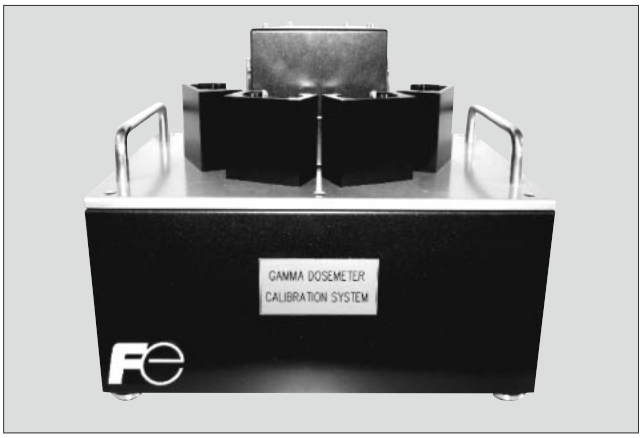
Available accessories for the electronic personal dosemeters include a setting device (Fig. 4) for setting a preset alarm value for the dose and cumulative time during operation, and a dosemeter calibrator (Fig. 5) for calibrating the measurement function of the electronic personal dosemeter.

Table 2 β-ray and neutron measurement ability of electronic personal dosemeter

Item \ Radiation detected	β-ray	Neutron
Energy range	300 keV to 2.4 MeV	0.025 eV to 15 MeV
Energy response	Within ±30 % (500 keV to 2.4 MeV)	Within ±50 % (100 keV to 4.5 MeV)
Angular response	Within ±30 % (up to ±60° in horizontal and vertical directions, $^{90}Sr^{90}Y$)	Within ±30 % (up to ±60° in horizontal and vertical directions, ^{241}Am-Be)
Accuracy (dose)	Within ±15 % (0.02 mSv or above)	Within ±15 % (0.5 mSv or above)
Linearity	Within ±20 % (0.1 $mSvh^{-1}$ or above)	Within ±20 % (0.5 $mSvh^{-1}$ or above)
Response time	Within 5 s (5 $mSvh^{-1}$ or above)	Within 5 s (100 $mSvh^{-1}$ or above)

Fig.4 Exterior view of setting device

Fig.5 Exterior view of portable dosemeter calibrator



5. Postscript

As for the future electronic personal dosemeters, higher performance and functionality including product development that conforms with the international standard IEC61526 (2005) are being requested and further improvements are needed.

To implement these improvements, Fuji Electric intends to continue to commercialize competitive devices that will not only maintain our market share in Japan, but that can also be deployed in overseas markets.

References

(1) Sasaki, M. et al. Development and characterization of real-time personal dosemeter with two silicons, Nucl. Instr. and Meth. A. no. 418, 1998, p. 465-475.

(2) Nunomiya, T. et al. Proceedings of 11th International Congress of the International Radiat. Prot. Dosim. Protection Association, Madrid, Spain, 2004-5, p. 23-28.

(3) Nunomiya, T. et al. Proceedings of the 10th Neutron Dosimetry Symposium, Progress in dosimetry of neutrons and light nuclei, Uppsala, Sweden, 2006-6, p. 12-16.

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