Environmental Radiation Measuring Equipment

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1. Introduction

Environmental radiation measuring equipment is commonly used at such facilities as nuclear power plants, research laboratories and hospitals for the purpose of measuring and controlling environmental radiation. Fuji Electric supplies various types of environmental radiation measuring equipment that support a variety of applications. In response to recent demands for environmental radiation measuring equipment that is smaller in size, has higher sensitivity and requires less labor, new products are being urgently developed to meet these needs.

This paper presents an overview of environmental radiation measuring equipment and introduces new models developed recently.

2. Environmental Radiation Measuring Equipment: Types and Uses

Fuji Electric's radiation measuring equipment can roughly be categorized as radiation control equipment, radiation monitoring equipment, and the detectors incorporated therein. Table 1 lists Fuji Electric's main products and their uses.

The survey meter is a representative example of radiation control equipment and is conveniently used to locate radiation leaks and search for surface contamination and radiation sources within a facility. Two types of recently developed radiation measuring equipment are introduced here, a low dose environmental dosemeter and a portable monitor post. Both of the radiation measuring devices have a simple configuration that can be connected to a PC for data processing, and they are portable for environmental dosimetry anywhere regardless of location. The low dose environmental dosemeter uses a semiconductor detector having approximately 100 times higher sensitivity than prior models (compared to prior models from Fuji Electric) and is capable of measuring low level doses. The portable monitor post uses a wide NaI (Tl) scintillation detector which is a single detector ranging from natural low dose rates to high dose rates.

Table 1 Main types of radiation measuring equipment

Type	Product name	Use	Measured radiation	Measurement range
Radiation control equipment	Ionization chamber type survey meter	1 cm dose equivalent, X instantaneous dose measurement	γ (X) rays, β rays	1 μSv/h to 30 mSv/h
	Scintillation type survey meter	Low level radiation monitoring and searching	α rays, β rays, γ rays	1 to 10^4 counts/s
	GM type survey meter	Measurement of leaking gamma doses and beta surface contamination	β rays, γ rays	1 to 10^5 counts/m
	Neutron REM counter	Measurement of leaking neutron doses	Neutrons	0.1 μSv/h to 9.999 mSv/h
	Personal dosemeter	Control of personal exposure at nuclear power facilities and the like	Neutrons, β rays, γ rays	0.01 to 1,000 mSv
Radiation monitoring equipment	Portable monitoring post	Outdoor environmental dosimetry	γ rays	10 to 10^8 nGy/h
	Low dose environmental dosemeter	Environmental dosimetry	γ rays	0.01 to 999,999.99 μSv/h
Detectors, etc.	Semiconductor area monitor detector	Monitoring and measurement of air gamma doses at radiation facilities	γ rays	0.1 μSv/h to 10 mSv/h
	Dust monitor semiconductor α-ray and β-ray detector	Counting of alpha and beta rays contained in airborne dust	α rays, β rays	1 to 10^5 counts/m
	Scintillation detector	Detector housed in a process monitor and the like	γ rays	Varies according to use
	γ-ray ionization chamber detector	Monitoring and measurement of air gamma doses at radiation facilities	γ rays	Varies according to use
	RI calibrator	Radioactivity measurement of medical radio isotopes used at hospitals	γ rays	0.1 MBq to 99.99 GBq

3. Low Dose Environmental Dosemeter NSD Series

3.1 Overview

Fuji Electric Systems and the Tsuruga Power Station of The Japan Atomic Power Company began to collaboratively develop a series of low dose environmental dosemeters in 2000, and realized a successful commercial product in March 2004. This newly developed low dose environmental dosemeter NSD3 has approximately 100 times higher sensitivity than the ones in the past, which enables low level measurement as low as 0.01 μSv, compared to the previous models that could not measure doses below 1 μSv. An internal battery is installed in the dosemeter storage post for three-month continuous monitoring that can provide a longer trend than conventional one-week trend. This allows data collection for a three-month dose trend as same as thermoluminescence dosemeters (TLD), a longtime environmental monitoring means in the vicinity of nuclear power plants. In terms of easy data collection mechanism, our environmental dosemeters excel the conventional thermoluminescences, which saved labor costs, and then were implemented as a replacement with TLD. The system process flow is shown in Fig. 1.

3.2 Features and specifications

(1) Low dose environmental dosemeter

Features are listed below.

(i) The structure of the main unit is water/splash-proof that resists condensation and splash.

(ii) The high sensitivity of the detector enables background (BG) level variation to be monitored.

(iii) Three channels of energy information data can be stored.

(iv) Non-contact communication (infrared communication) is provided to communicate with its data collection terminal.

(v) Measurement data are stored in non-volatile memory so that the data can be read in an event of NSD3 malfunction.

Main specifications are listed in Table 2.

(2) Data collection terminal

The data collection terminal can store measurement results of the low dose environmental dosemeter and the features are listed below:

(i) Small size and light-weigh. Carried with the shoulder strap.

(ii) The terminal can collect and store three-month cumulative data from a maximum of 20 low dose environmental dosemeters NSD3.

(iii) Can maintain the data after battery expiration.

(3) Data processing system

Data stored in the data collection terminal are transferred through an RS-232C cable to a data processing unit (PC). The stored data can be displayed as a list of a 1-hour cumulative dose or as count values per energy level. If a large fluctuation in a trend data is observed, 1-minute trending feature is available for that data sampled to analyze in detail.

(4) Post for low dose environmental dosemeters

A battery is installed inside the dedicated dosemeter storage post for continuous low dose environmental dosimetry for three months or longer. The post has good ventilation to prevent an increase in internal temperature when exposed to direct sunlight, and water-resistant design that prevents rainwater infiltration. Even if installed in the post, the low dose environmental dosemeter NSD3 is able to communicate with the data collection terminal.

3.3 Characteristic data of the low dose environmental dosemeter

The dose rate linearity, at relative sensitivity (^{137}Cs reference), is within ±10 %. Also, angular responses (vertical and horizontal) for the low dose environmental dosemeter NSD3 when installed in the post are within ±30 % (^{137}Cs reference), (not including the dead zone due to the battery). Angular responses are shown in Fig. 2.

Fig.1 Process flow for a low dose environmental dosemeter system

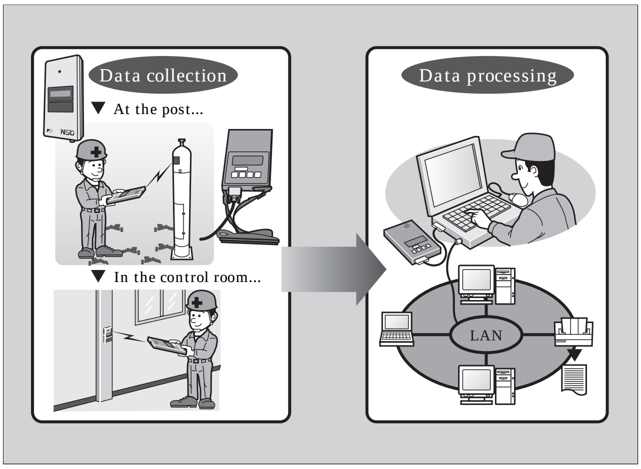


Table 2 Specifications of the low environmental dosemeter NSD3

Item	Description
Radiation detected	γ (X) rays
Energy range	50 keV to 6 MeV
Measurement dose	0.01 to 999,999.99 μSv
Accuracy of reading	±10 % (^{137}Cs)
Angular response	±30 % (excluding dead zones)
Ambient temperature	−10 to +50°C
Size	80 (W)×140 (D)×29 (H) mm
Mass	Approx. 300 g

Fig.2 Angular response of low dose environmental dosemeter when installed in the post

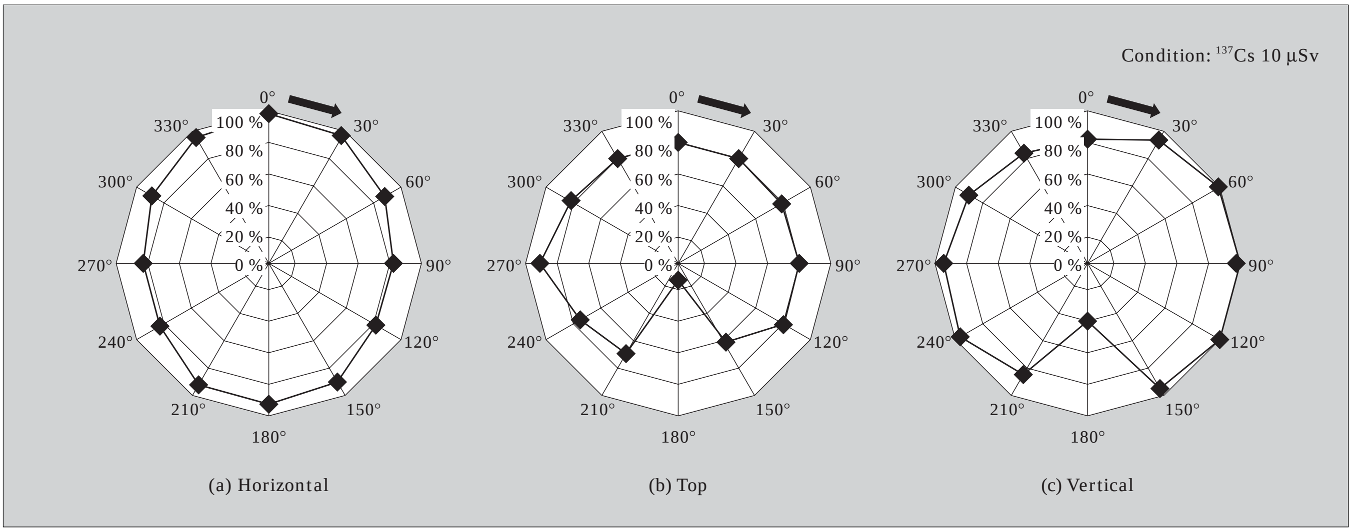


Fig.3 Comparison with monitoring post

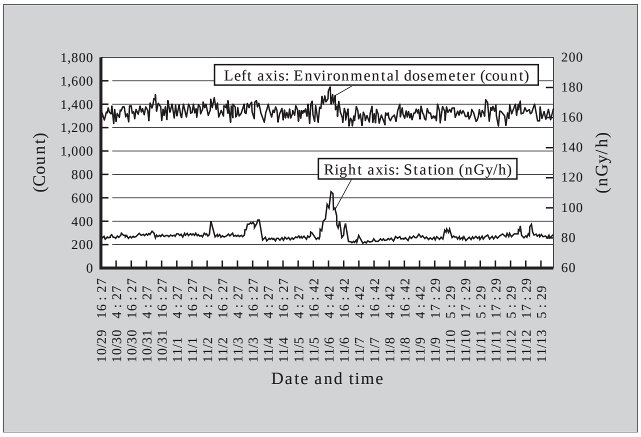


Fig.4 Appearance of the portable monitor post

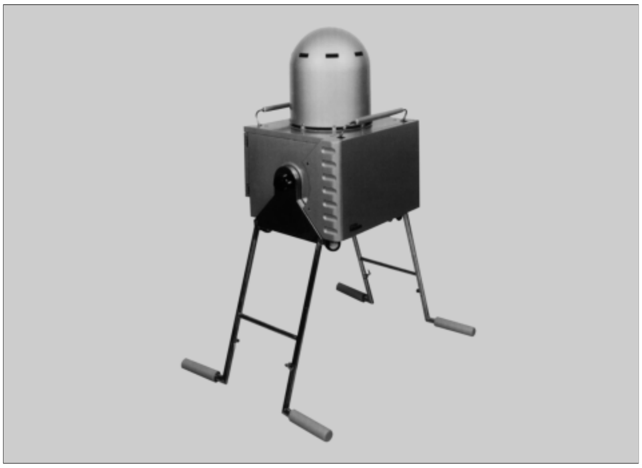
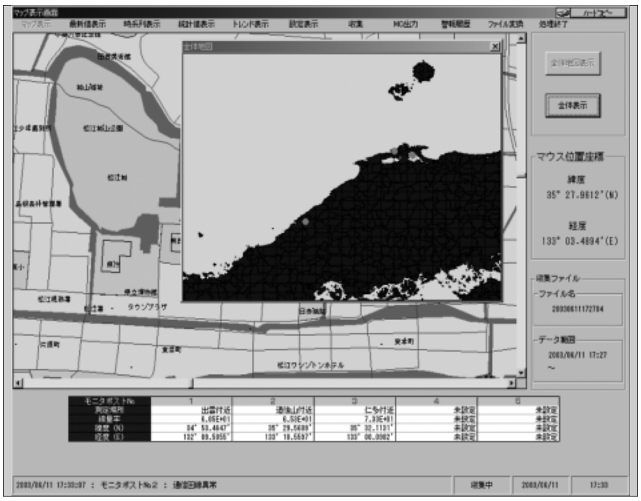


Fig.5 Example of environmental radiation dose rate map



3.4 Field comparison data

Comparison data for the low dose environmental dosemeter and a monitoring post (NaI detector) is shown in Fig. 3. Low dose environmental dosemeter readings (count values) follow fluctuations in monitoring post readings (nGy/h). This indicates that dosemeter is able to measure the background level doses with high precision.

4. Portable Monitor Post

4.1 Overview

The portable monitor post uses a wide NaI (Tl) scintillation detector and is able to measure air gamma dose rates over a wide range from the BG level to 10^8 nGy/h. Featuring compact size and light weight, this portable monitor post can easily be transported and used for measurement. An internal global positioning system (GPS) and data transmission terminal enable transmission of dose rate and position information via a cell phone or other systems. For this reason, the portable monitor post is used as an environmental radiation monitoring post for emergency responses. Its external appearance is shown in Fig. 4.

An example of an environmental radiation dose rate map that uses the dose rate and location informa-

Table 3 Specifications of the portable monitor post

Item	Specification
Dose rate measurement range	10 to 10^8 nGy/h Low range region : 10 to 5×10^5 nGy/h High range region : 3×10^5 to 10^8 nGy/h
Dose rate measurement accuracy	±10 % (reference : for ^{137}Cs exposure)
Angular response	±20 % (0 to ±90°)
Energy response	Low range area : ±20 % (from 50 keV to less than 100 keV) ±10 % (from 100 keV to 3 MeV) High range area : −50 to +25 % (from 50 keV to less than 100 keV) −10 to +20 % (from 100 keV to less than 400 keV) ±10% (from 400 keV to 3 MeV)
Variation of indications	Coefficient of variation: 0.1 or less
Temperature characteristics	±5 % (20°C reference)

tion is shown in Fig. 5.

4.2 Features

The features are listed below:

(1) The portable monitor post may be used as a backup for non-moveable environmental radiation monitors.

(2) Compact size and lightweight structure of the portable monitor post makes it easy to transport and install.

(3) All-weather type for outdoor installation. Can be powered by an external battery when installed in where AC power is unavailable.

(4) Internal memory can store a 1-week measurement values (values measured every 1 minute).

(5) An energy response compensation circuit and a temperature compensation circuit are provided.

4.3 Specifications

The specifications are listed in Table 3.

4.4 Characteristics

So that a single detector can cover measurements in the range of 10 to 10^8 nGy/h, the detector is used differently for the low and high range regions. For the low range region, it is used as a pulse-output type detector and for the high range region, it is used as a current-output type detector. Energy responses for each region are shown in Figs. 6 and 7.

Fig.6 Energy response in low range region

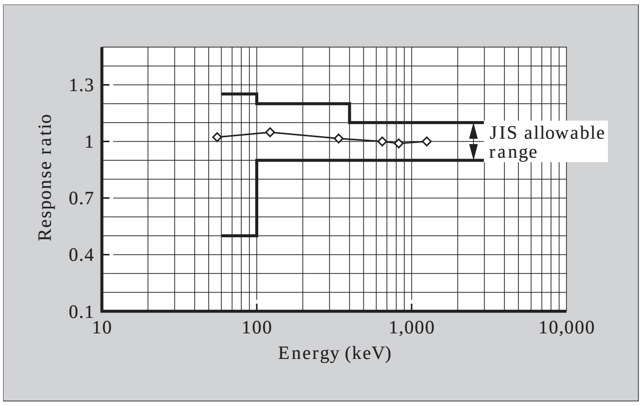
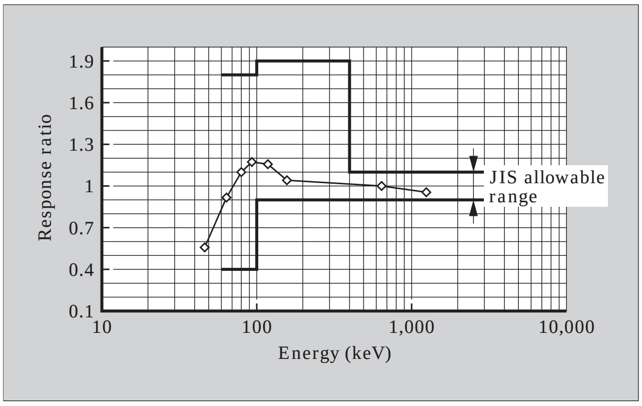


Fig.7 Energy response in high range region



5. Conclusion

The objectives of radiation control are to reduce exposures much further, to save labor and enhance functionality for dosimetry. Because the low dose environmental dosemeter and the portable monitor post achieve nearly the same performance as conventional large-sized measuring equipment and can store greater quantities of radiation data, future applications are expected. In the future, Fuji Electric intends to improve the performance in low energy and angular response.

In conclusion, the authors wish to express their gratitude to all members of the Environmental Safety Department of The Japan Atomic Power Company's Tsuruga Power Station from whom we received guidance and data useful in the development of the low dose environmental dosemeter.