

Environmental Radiation Monitoring System

Tsutomu Kato
Masatoshi Shioiri
Tsuyoshi Sakamaki

1. Introduction

An environmental radiation monitoring system (hereafter referred to as the system) is a significant system for measuring environmental radiation levels at the boundaries of monitoring areas surrounding a nuclear facility and in the surrounding regions, and for monitoring the radiation exposure to residents in the surrounding regions.

This paper presents an overview of the system and describes new functions that have been developed to improve the reliability of measurement data.

2. Overview of the System

The system is configured from a dose rate measurement device, a dust monitor, and an iodine monitor. Weather observation facilities, a telemeter, and an environmental monitor panel and computer installed in a central control room may also be connected to the system. Figure 1 shows an example system configuration and Fig. 2 shows an example installation for dose rate measurement.

Additionally, in order to supplement the measurement of the dose rate and to respond to emergencies, a mobile monitoring car equipped with a dose rate measuring system can also be provided as a part of the system, and Fig. 3 shows an example of the monitoring car.

Fig.1 System configuration example

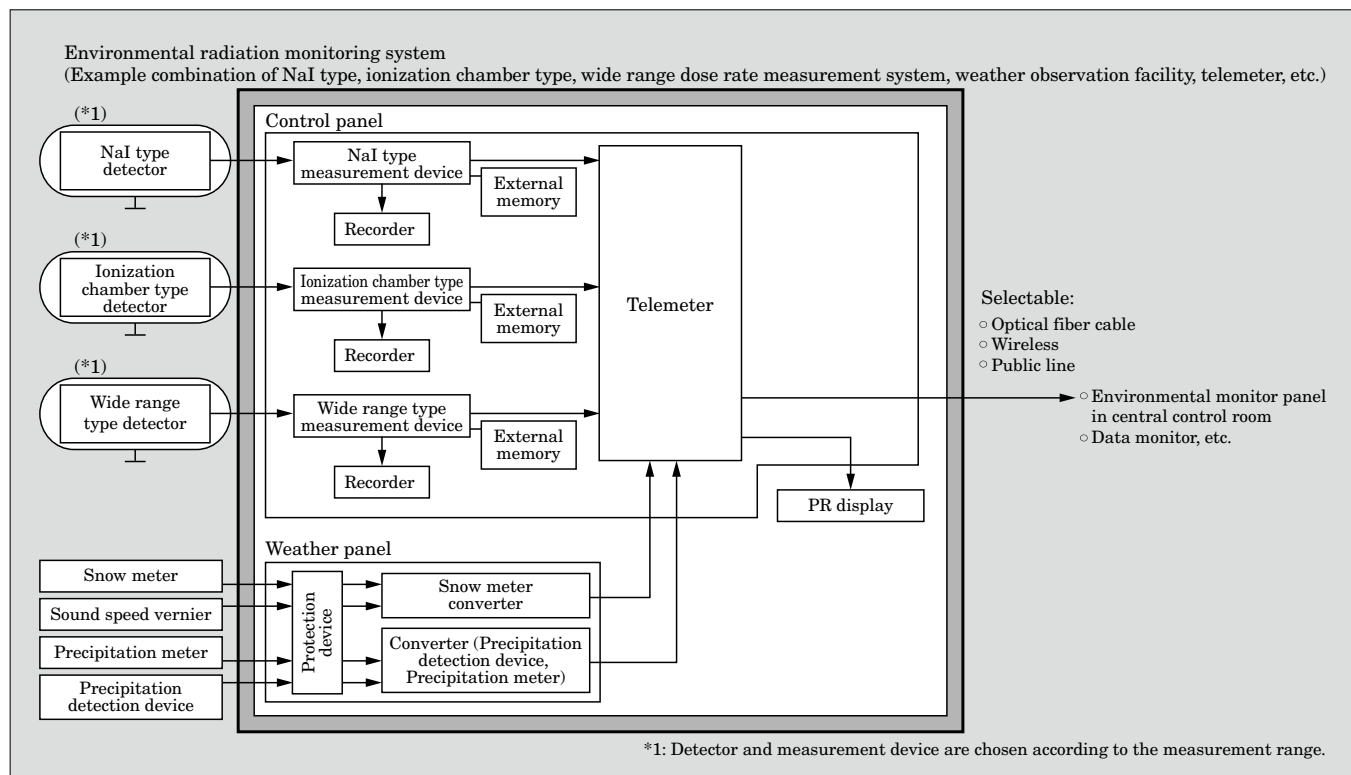


Fig.2 Example of installation for dose rate measurement device



Fig.3 Example of the monitoring car



Table 1 Specification table of dose rate measurement systems

Item	NaI type radiation dose rate measuring system	Ionization chamber type dose rate measurement system	Wide range radiation dose rate measurement system
Detector	NaI (Tl) scintillation detector	Ionization chamber detector	NaI (Tl) scintillation detector (with lead filter)
Detector size	2 "dia. × 2"	Approx. 14.5 L	2 "dia. × 2"
Measurement range	BG level to 10^5 nGy/h	BG level to 10^8 nGy/h	BG level to 10^8 nGy/h
Display error	Within ± 10 %	Within ± 10 %	Within ± 20 %
Energy characteristic	50 keV to 3 MeV : Within ± 10 %	50 keV to 400 keV : Within ± 15 % 0.4 to 3 MeV : Within ± 10 %	50 keV to 100 keV : Within ± 20 % 50 keV to 3 MeV : Within ± 10 %
Direction characteristic	Within ± 10 %	Within ± 3 %	Within ± 10 %
Temperature characteristic (20°C reference)	Within ± 5 %	Within ± 5 %	Within ± 5 %

2.1 Dose rate measuring system

The dose rate measuring system is configured from a detector and measuring device. Three types of dose rate measuring systems exist according to the dose rate range to be measured: the NaI type, the ionization chamber type and the wide range type.

(1) NaI-type of dose rate measuring system

The NaI-type of dose rate measuring system is capable of measuring the region from 10 to 10^5 nGy/h. The detector is equipped with a NaI (Tl) scintillator, a photomultiplier, an amplifier, a high voltage power supply and a temperature compensation circuit, and outputs standardized pulse signals without any temperature dependence. The measurement device is equipped with an approximate 6-inch TFT color LCD display, a CPU for measurement-use with an energy compensation circuit, and a CPU for displaying, transmitting and storing the measurement data. Moreover, the energy compensation method employs a DWM (digital weighting method) that uses a G (E) function so that measurement data is counted with a high degree of accuracy and converted into the dose rate, and a spectral data aggregation function simultaneously enables the radioisotope to be identified from the gamma-ray energy data.

(2) Ionization chamber type dose rate measurement

system

The ionization chamber type dose rate measurement system is capable of measuring the region from the BG (background dose rate) level to 10^8 nGy/h. The detector is equipped with an ionization chamber, an amplifier, a voltage-frequency conversion circuit and a high voltage power supply, and the measurement device counts frequency pulses from the detector and displays the dose rate data. Also available is a type in which the material used for the case of the spherical ionization chamber has been changed from the conventional stainless steel to aluminum, which has a smaller specific gravity, and that measures gamma rays with improved accuracy in the low energy region of 400 keV and below.

(3) Wide range dose rate measurement system

The wide range dose rate measurement system adds to the NaI-type dose rate measurement system an auxiliary measurement function for measuring the high dose rate region assumed in the case of an accident, and is capable of measuring the region from the BG (background dose rate) level to 10^8 nGy/h with the combination of a single detector and a measurement device. With the combination of a detector and a measurement device, the low dose rate region of the BG level to 10^5 nGy/h is measured and processed with pulse signals from the detector, and for the high dose

Fig.4 Portable iodine monitor



rate region of 10^5 nGy/h and above, for which pulse measurement is not possible, a method is adopted in which a current signal proportional to the dose rate is measured and processed.

Main specifications of the NaI type dose rate measurement system, the ionization chamber type dose rate measurement system, and the wide range dose rate measurement system are listed in Table 1.

2.2 Dust monitor, iodine monitor

The dust monitor continuously measures the concentration of radioactive dust in the air. The dust monitor is integrated with a dust sampler. The detector uses an alpha-beta coincidence counting method that combines a plastic scintillator for measuring beta-rays, and a ZnS scintillator for measuring alpha-rays. Moreover, a function for automatically sampling radioactive iodine in a charcoal cartridge is added for cases where the dose rate of environmental gamma-rays exceeds a preset warning level. Furthermore, a portable radioactive iodine monitor is also available for sampling and measuring the radioactive iodine. (See Fig. 4.)

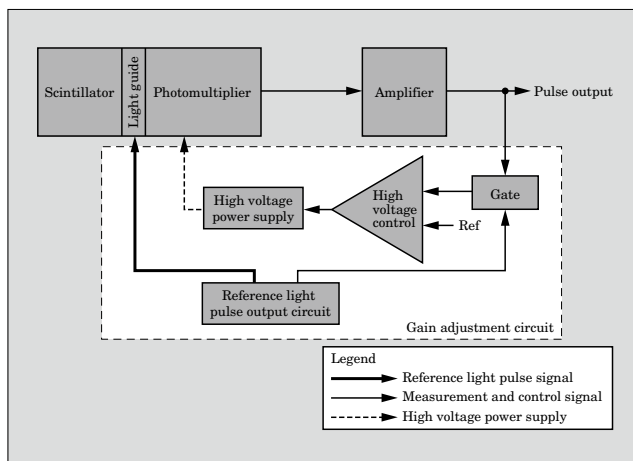
2.3 Telemeter

The transfer of data from a monitoring post to a monitor panel in a central control room can be implemented with a transmission system adopting a telemeter using a programmable controller having high reliability and a successful track record for 24-hour continuous operation. The transmission pathway can be selected as a fiber optic cable, wireless transmission such as with a cell phone, or a public line.

3. New Functions

(1) NaI type dose rate measurement system

Fig.5 Schematic diagram of automatic gain adjustment



(a) Spectral data output function

The measurement device is provided with a function for setting four predetermined energy regions for the aggregated spectral data to enable the radiation dose of each region to be assessed. For example, by setting these energy regions to the natural radiation region, the man-made radiation region, and the energy region of radiation used for radiotherapy, it is possible to assess which region's radiation has caused a rise in the measured value.

(b) Automatic gain adjustment function

The automatic gain adjustment method was developed to improve the reliability of measured data. As a method to prevent gain drift, an LED light source is inserted into the detector, a reference pulse is inputted continuously, and a function is provided that checks the peak channel position on a minute-by-minute basis. Figure 5 shows an overview of the automatic gain adjustment function. In the case where the measured peak channel position has drifted from the reference channel to a value greater than the standard value, the amplifier gain is adjusted automatically so that data can be acquired without being affected by gain drift.

(2) Dust monitor

The naturally occurring radionuclides of the uranium and thorium series exist in nature as background radiation. The radiation emitted from these radionuclides are nuclides that interfere with counting by the dust monitor, and if the measurement data fluctuates, whether that fluctuation is due to a fluctuation in natural radiation or due to an increase in radiation levels from the facility cannot be determined. Previously, many methods for removing these interfering nuclides have been tried, and introduced here is the alpha-beta coincidence count method that has been commercialized by Fuji Electric. This method is applicable to a wide range of products, including monitoring posts. The principles of this method are described below.

Fig.6 Decay scheme of radon (Rn) series

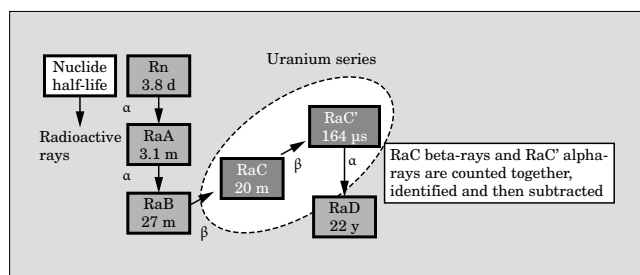
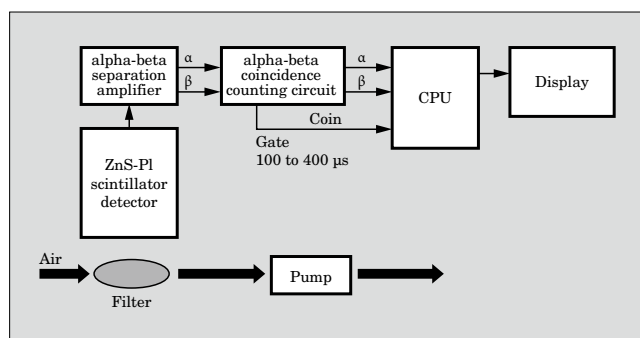


Fig.7 Schematic diagram of the alpha-beta coincidence counting circuit

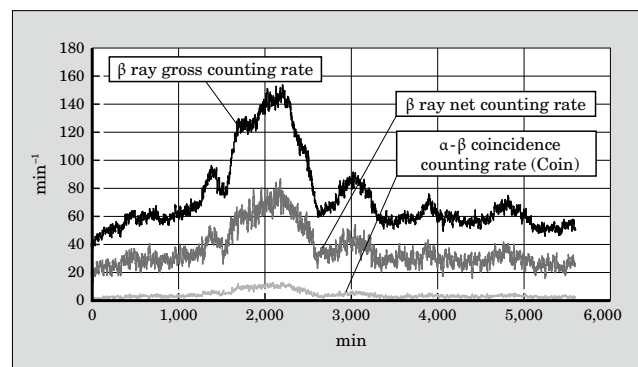


(Principle of subtraction by alpha-beta coincidence counting)

Each radionuclide emits a certain type of radiation for a certain time duration and then changes into another atomic nucleus, and the halfway point for that change is known as the half-life. Figure 6 shows the decay scheme of the radon series of natural radiation.

In consideration of the half-life of RaC and RaC' shown in Fig. 6, the subtraction method counts both the beta-rays and alpha-rays emitted within the extremely short time of 164 μ sec. In other words, these alpha-

Fig.8 Subtraction effect of the alpha-beta coincidence counting method



rays and beta-rays are regarded as an alpha-beta coincidence signal (Coin), and a CPU subtracts them from all counted values, so that the effect of natural radiation emitted from RaC and RaC' can be eliminated. Figure 7 shows a schematic diagram of the alpha-beta coincidence counting circuit. Moreover, Fig. 8 shows the subtraction effect of the alpha-beta coincidence method. Use of this subtraction method enables the background influence to be reduced by approximately half.

4. Postscript

Fuji Electric has been building highly reliable systems that utilize comprehensive technology including radiation measuring and data transmission techniques and the like.

In the future, based on this radiation measuring technology, Fuji Electric intends to build monitoring systems that are even more compact and have lower cost.

~~~~~



\* All brand names and product names in this journal might be trademarks or registered trademarks of their respective companies.