Real-Time Remote Monitoring System Utilizing New Electronic Personal Dosimeter

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ABSTRACT

Conventional radiation exposure management methods included sounding a dosimeter alarm when a measured value reaches a pre-set exposure dose level to prevent further exposure. Meanwhile, the real-time remote monitoring system enables managers to monitor the exposure dose of workers in real time and give workers appropriate instructions before the alarm of the pre-set level is raised to prevent unnecessary exposure. The new electronic personal dosimeter developed by Fuji Electric can use cloud servers, web applications, and Wi-Fi compliant general-purpose access points, allowing constructing a real-time remote monitoring system with low initial investment.

1. Introduction

Fuji Electric has been focusing on developing radiation management solutions, and in particular, we have been maintaining the top market share in the Japan for its electronic personal dosimeters for use in nuclear power plants.

In order to manage exposure to radiation, workers are required to wear a personal dosimeter, which comes in 2 different types: a passive-type and an active-type. Passive-type personal dosimeters require that a special device be used approximately once a month to analyze the exposure dose. In contrast to this, active-type personal dosimeters are capable of real-time measurement of exposure doses, and they help workers avoid unnecessary exposure doses through raising an alarm, etc.

The real-time remote monitoring system comes equipped with an active-type personal dosimeter, and this enables managers to monitor the exposure dose and give workers appropriate instructions even when the display of the dosimeter cannot be verified due to working conditions. As a result, it can be expected that the exposure dose will be reduced even further.

In this paper, we will introduce the real-time remote monitoring system, which can be easily adopted in hospitals, laboratories, universities and other places that are equipped with a Wi-Fi network.

2. Real-Time Remote Monitoring System

Radiation management requires that "economic and social factors be taken into consideration, reduce every dose as low as reasonably achievable" based on the concept of ALARA (as low as reasonably achievable), a key guiding principle recommended by the International Commission on Radiological Protection (ICRP) in 2007 . In order to achieve this, the exposure dose must be actively reduced. However, the conventional radiation exposure management method included raising a dosimeter alarm to notify workers when the measured value reaches the pre-set exposure dose level to prevent further exposure. As a result, exposure needed to be tolerated until raising the alarm.

On the other hand, the real-time remote monitoring system enables managers to monitor the exposure dose of workers in real time and give workers appropriate instructions before the exposure dose reaches the pre-set level at which an alarm is raised. Therefore, unlike conventional systems, where action could only be taken after being exposed, this system enables taking measures to avoid unnecessary doses of exposure by alerting workers to locations of unexpectedly high dose rates either before or during the process of work. There are already some cases in the United States where the adoption of the real-time remote monitoring system has contributed significantly in reducing the exposure dose of workers, and we believe that the use of this system will also become widely adopted in Japan in the future.

2.1 System configuration

The real-time remote monitoring system connects approximately 10 dosimeters to 1 repeater; and in a typical configuration it transmits measurement data on the aggregated exposure dose and dose rate to a server in real-time. An installed repeater monitors the entire area by spanning the regions covered by each unit. The repeater communicates with dosimeters in its network and other repeaters wirelessly, and transmits data to the wireless master unit. The

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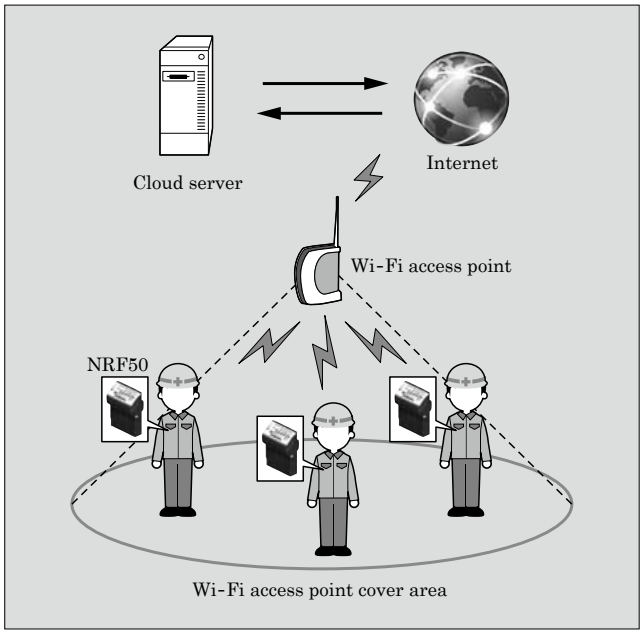

Fig.1 Configuration example for the real-time remote monitoring system using Wi-Fi

wireless master unit connects to higher-level networks using Ethernet*1 or other protocols to transmit the data. However, the adoption of the system requires a substantial amount of time and cost since the use of wireless is restricted to frequency bands that comply with each individual country's regulations; opening a wireless base station requires registration application; and dedicated equipment needs to be procured to begin operations. Therefore, Fuji Electric is proposing to construct a Wi-Fi*2 based real-time remote monitoring system for hospitals, laboratories and universities. Since a Wi-Fi compliant general-purpose access point can be procured inexpensively, initial investment can be kept low. Furthermore, by utilizing a cloud server and web application, operations can be commenced without the need of purchasing new equipment. A configuration example for the system that utilizes Wi-Fi is shown in Fig. 1.

2.2 Function overview

All information and data can be managed collectively through the web application or management software installed in the operation terminal on the network. The data for the applicable area's dosimeter, area monitor and camera can be checked by displaying a list.

The real-time remote monitoring system is not only capable of confirming worker exposure dose data in real time and on-site dose rate data, but can also reflect dose rate data into work-site maps and confirm on-site camera images. Therefore, instructions to evacuate or move locations can be quickly given to workers. In addition, by utilizing the benefit of real-time data acquisition, incidents of overexposure can be prevented for areas of unusually high radiation doses and for workers who cannot personally check their dosimeters. Furthermore, the accumulation of daily records and data can be helpful in creating efficient work plans and establishing restricted access areas.

2.3 New electronic personal dosimeter

The new electronic personal dosimeter "NRF50" developed by Fuji Electric is the core instrumentation device of the real-time remote monitoring system; and it was developed based on our rich experience of understanding and fulfilling customer needs. As main features, the device comes equipped with a wireless module integrated structure, an easy-to-see display and an emergency call button.

In addition to having high measurement accuracy, a personal dosimeter is required to be compact, lightweight and support long-time operation so that workers can wear it while working. Accordingly, the NRF50 was developed to meet these requirements using the following technologies:

(a) A compact design that achieves a built-in wireless module instead of the conventional external unit
(b) A sensor shield design that prevents wireless interference on measurement performance
(c) Optimization for the power circuit design and operation sequence that enables measuring for 8 hours or more while operating the wireless module, without replacing batteries

The external appearance of the NRF50 is shown in Fig. 2, and the major specifications are shown in Table 1.

(1) Wireless module

In conventional real-time remote monitoring systems, the wireless module is incorporated into the system by mounting a wireless attachment to an existing dosimeter. Existing dosimeters have the benefit

Fig.2 "NRF50"

*1: Ethernet is a trademark or registered trademark of Fuji Xerox Co., Ltd.
*2: Wi-Fi is a trademark or registered trademark of Wi-Fi Alliance.

Table 1 "NRF50" specifications

Item	Specification
Measurement type	Gamma ray
Detector	Silicon semiconductor
Measurement range	1 μSv to 10 Sv
Energy characteristic	± 20% (50 keV to 6 MeV)
Directional characteristic	± 20% (Cs-137, 0° to 75°)
	± 50% (Am-241, 0° to 75°)
Indication error	± 10% (Cs-137)
Waterproof performance	IP65, IP67
Alarm volume	90 to 100 dB (at distance of 30 cm)
Communication functions	Electromagnetic induction, infrared, USB, Bluetooth, 900 MHz/Wi-Fi
Data storage	Max. 4,000 items (date, dose, dose rate, status)
Temperature	−10 °C to +50 °C
Humidity	up to 95% RH
Battery	2 AA batteries
Continuous operating time*	2,500 hours or more
Dimensions	W 60 × D 29 × H 105 (mm)
Weight	Approx. 170 g (including batteries and clip)

*When new AA alkaline batteries are used, and the alarm and Wi-Fi are not in use.

of being used as standalone units, but they are bulky and heavy. Therefore, the NRF50 is not based on an attachment, but is an integrated unit with the wireless module built into the unit body.

The mounted wireless module supports selection of Wi-Fi or 900-MHz wireless, and in the future, we plan to add other frequency bands for the wireless. The data transmission cycle can be set to 2, 4, 10, 30 or 60 seconds. The Wi-Fi module is compliant with the WPA, WPA2 and WEP encryption standards. When using 2 AA alkaline batteries, the unit can be used for 8 hours or more at a data transmission cycle of 10 seconds.

(2) Display

In order to improve visibility, it adopted dot type LCD with a display area of W 43.5 × H 16.3 (mm) to display numbers as large as possible. The display is nearly twice as large as those of other companies. Furthermore, it also comes equipped with a white, red and orange colored backlight, and alarms can be easily notified to workers by indicating the configured display.

(3) Emergency call button

The most distinctive feature not available with conventional products is the adoption of an emergency call button. Emergency messages can be transmitted to the server via wireless telemetry by simply pressing this button. In addition, enforced emergency alarms can be sent from the server to workers.

Fig.3 Heart rate meter

2.4 Application examples

In addition to managing exposure doses with the real-time remote monitoring system, the use of the functionality of the new electronic personal dosimeter enables supervisors to manage the safety of workers with more care and precision.

(1) Abnormality detection in worker's body

Since the unit comes with a built-in acceleration sensor, it can detect the state in which a worker who is wearing the dosimeter is unable to move. It is also able to detect when workers collapse, which is something that can happen unexpectedly. By including this type of information into the remote monitoring system, it has now become possible to respond to urgent time-sensitive situations.

(2) Worker heart rate monitoring

Since the unit is equipped with Bluetooth*3, it can be connected to the heart rate meter (see Fig. 3) manufactured by POLAR. By constantly monitoring the heart rate of workers who have chronic diseases, unexpected situations can be prevented before they happen.

(3) Simple area monitor

The dosimeter has a lower sensitivity than detectors used by conventional area monitors. Furthermore, since the unit is calibrated for managing the exposure dose while it is being worn on the body, scenarios in which the unit is installed somewhere to measure aggregated doses and dose rates have not been considered. However, it is capable of detecting sudden increases in dose rates, and as a result, it can be used as a simple area monitor. Since the NRF50 can be operated while power is supplied through a USB cable from an external device, it can be incorporated into real-time remote monitoring systems as an area monitor without concern for battery life.

3. Future Outlook

Currently, only the "NRF50" is available as a device compatible with this real-time remote monitoring system, but we plan to expand the lineup for the series by releasing the "NRF51" as a unit capable of measuring gamma ray and neutron, and the "NRF54" as a

*3: Bluetooth is a trademark or registered trademark of Bluetooth SIG, Inc.

unit capable of measuring gamma ray and beta ray. Moreover, in the United States, by using other wireless frequencies in addition to 900 MHz,

it is expected that the unit can be used domestically and abroad in outdoor decontamination work and in countermeasures to terrorism by radioactive material. Furthermore, it can be expected that there will be an expansion of use in European countries with the acquisition of the CE marking.

4. Postscript

In this paper, we described the real-time remote monitoring system that utilizes the new electronic personal dosimeter. We plan to continue to offer a wide range of solutions that incorporate system engineering technologies based on customer needs.

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