Development of personal dose monitoring system using wireless data transmission device

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Abstract. Radiation workers working in radiation controlled area in nuclear power plants etc., are required to carry a dosimeters by regulation law. The workers are controlled daily on personal exposure dose by reading out the exposure dose information of the dosimeters with an area access control gate installed at the entrance of the radiation controlled area. This type of personal dose monitoring system has a problem that each worker can get his personal dose data only at the entrance of the radiation controlled area several times a day. We developed a system to get the real-time acquisition of personal dose data especially for workers working in a high dose area. This system is generally composed of a dosimeter with a wireless attachment, relay station, and monitor. Some relay stations set in main work places in the radiation controlled area can collect real-time personal dose data of each dosimeter carried by workers at the work place with the relay stations, and transmit it to the monitor to get personal dose data of individual workers. A wireless communication system between dosimeters and relay stations is applied to collect efficiently all personal dose data in the work place.

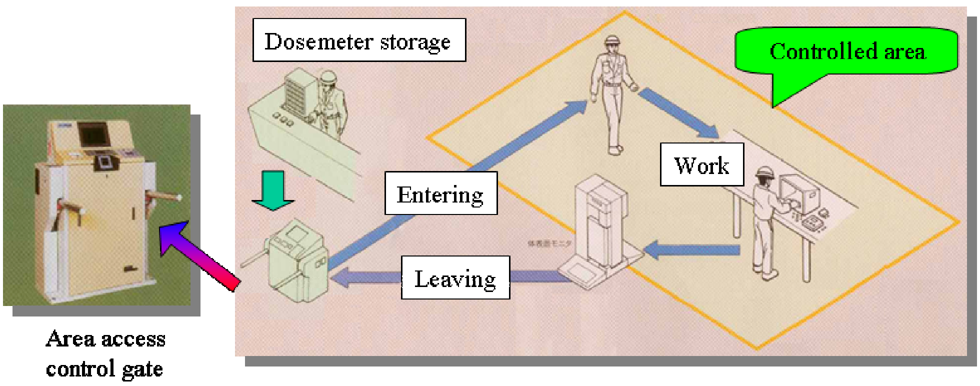
KEYWORDS : personal exposure control system, wireless communication, real-time

1. Introduction

Radiation workers working in radiation controlled areas in nuclear facilities are required to carry a personal dosemeter by regulation law. Figure 1 shows the configuration of a conventional personal dose monitoring system employed at an area access control gate. An area access control gate is installed at the entrance of the radiation controlled area, and the information on the personal dose data with each worker's ID number, stored in the memory of a personal dosemeter, is transmitted from the personal dosemeter to the area access control gate. In a conventional system, the personal dose data obtained in the controlled area is confirmed through the LCD display on a dosemeter, or the sound from an alarm buzzer when the dose data reaches a certain warning level. The conventional system, however, has a problem that each worker can get his personal dose data only at the entrance of the radiation controlled area several times a day. Therefore, it is strongly desired to get the real-time acquisition of personal dose data, especially for workers working in a high dose area.

In response to this requirement, we developed a new personal dose monitoring system using wireless data transmission device to realize the real-time personal dose acquisition.

Figure 1 Dose monitoring system with area access control gate



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2. System overview and system specifications

In order to realize the real-time data acquisition, a wireless attachment is mounted onto each personal dosemeter for use in the radiation controlled area, and the signals from a number of personal dosemeters are transmitted to the data processing unit through the relay stations. This system is able to monitor the dose data of a few to several tens of workers in the radiation controlled area with a cycle time of several seconds to several minutes and any information on warning can be transmitted in real-time from the monitoring system directly to each personal dosemeter. This system is also applicable to: 1) monitoring the dose data during normal operation (monitoring many workers with a cycle time of several minutes), 2) real-time monitoring of the individual data of workers working in a high radiation dose area (monitoring a few workers with a cycle time of several seconds), and 3) simplified area monitoring using personal dosemeters.

A newly-developed personal dose monitoring system shown in Fig. 2 is configured from a personal dosemeter (NRF-30 and NRF-31) with a wireless attachment, a relay station and a data processing unit. The wireless attachment, as shown in Fig. 2,consists of an attachment mountable to the personal dosemeter containing a built-in silicon radiation sensor and a wireless unit for implementing the wireless transmission of dose data from the dosemeter to a relay station. The personal dosemeter is also provided with an infrared communication function so as to be able to transmit the dose data externally. An infrared communication function installed in the wireless attachment is used to transmit the dose data between the personal dosemeter and the wireless unit. The relay station shown in Fig. 2 is used to store the dose data temporarily from multiple wireless attachments and to transmit the data to a data processing unit. The data transmission to the upper-level data processing unit can be selected from the following three ways: 1) a PHS-based communication method (local area circuit), 2) an Ethernet-based communication method, or 3) a RS-232C-based communication method (for uploading data directly to a data processing unit). The relay stations shown in Fig. 2 are an example of a PHS-based communication method.

Figure 2 Personal dose monitoring system using wireless data transmission device

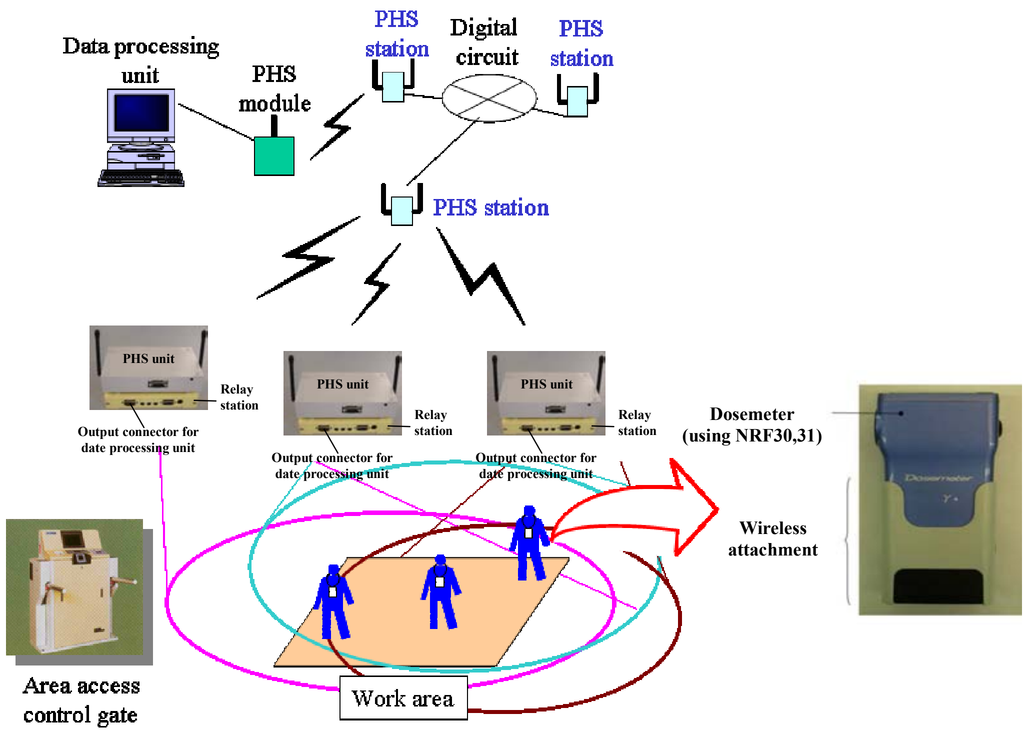
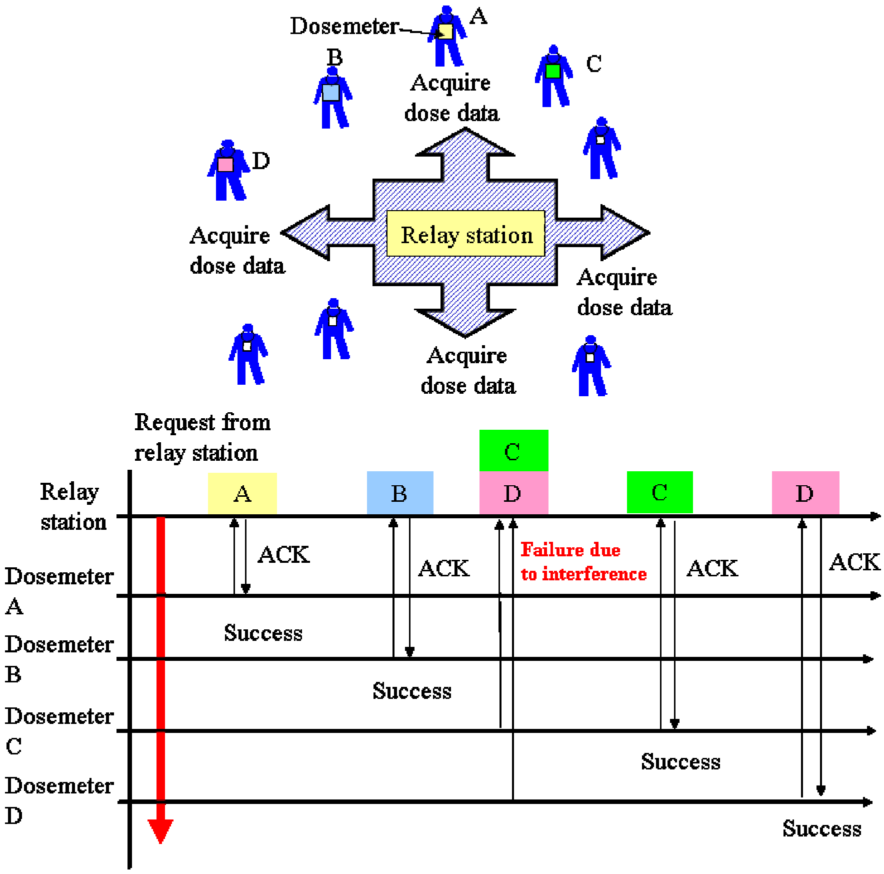


Figure 3 depicts the operation principle of the monitoring system in the case where an unspecified large number of workers are present in a radiation controlled area and the dose data must be acquired. At the prescribed cycle time, the relay station requests the dose data from the wireless attachments carried by the workers. The dose data request signal received by a wireless attachment is converted from an electrical signal to an infrared optical signal and transmitted to the personal dosemeter. In response to the data request, the personal dosemeter transmits the dose data as an optical signal to the wireless attachment through a built-in infrared communication function. The wireless attachment then transmits the dose data to the relay station at a random timing to decrease the risk of interfering with a wireless signal from a wireless attachment carried by another worker. If there is no interference, the dose data is transmitted to the relay station and the wireless attachment receives an ACK signal from the relay station indicating the communication success. If there is an interference, however, an ACK signal does not come from the relay station and the transmission will be repeated again at a random timing to avoid the interference. By repeating this communication at a prescribed cycle time, this communication method can achieve a success rate of nearly 100%.

Figure 3 Operation principles of the monitoring system



The dose data from multiple wireless attachments are first stored in a memory inside the relay station. Then, at the predetermined cycle time, in response to the data request from the data processing unit for reading out the signals, the relay station transmits the dose data stored in the memory to the data processing unit. The data communication method to be used here can be selected from one of the three methods described before. The main specifications of this monitoring system are listed below.

(1) Monitoring cycles: 15s to 1 min,
(2) Wireless attachments to be monitored: 10 to 50 units,
(3) Monitoring area: Several tens of meters around 10 × 10 m for 50 units.

The monitoring interval can be set to approximately 15 seconds for a small number of workers, or to approximately 1 minute for a large number of workers. As an example, in the case of 50 wireless attachments, the sampling interval will be approximately 1 minute.

3. Device features and specifications

3.1 Personal dosemeter

Personal dosemeter in this system is made of silicon semiconductor detector. NRF30 uses a 3-mm by 3-mm silicon for gamma-ray detection and NRF31 uses three silicon detectors, the same one for gamma-ray detection and two 10-mm by 10-mm silicon detectors with polyethylene and boron radiators for fast and slow neutron detection[1]. The dosimeter has a pocket size of 78-mm height, 60-mm width, 27-mm thickness and light weight of 103 g.

3.2 Wireless attachment

The wireless attachment having an attachment function is capable of encapsulating the personal dosemeter (NRF30 and NRF31 dosemeters). The wireless attachment is also provided with a function for converting the infrared optical signal from the personal dosemeter into an electrical signal. The wireless communication between relay stations is implemented using a specified low power wireless communication, and the frequency of this specified low power wireless communication can be adjusted for use overseas. Since the wireless attachment and the personal dosemeter are electrically isolated, the wireless attachment is equipped with a rechargeable AAA-size battery (nickel hydride). At the bottom of the wireless attachment is provided a terminal for connecting a charging device, and the battery can be recharged via this terminal. A commercially available ordinary AAA battery may also be used. The main specifications of the wireless attachment are listed in Table 1.

Table 1 Wireless attachment specifications

Item	Details
Wireless specification	Specified low power wireless Communication (Japanese standards)
Wireless frequency	429.500MHz (tunable to other frequency bands)
Transmit power	0.01W
Transmission rate	4,800 bps
Continuous Operation time	Approx. 30h (When communication once per minute)
Current consumption	Approx. 17 mA

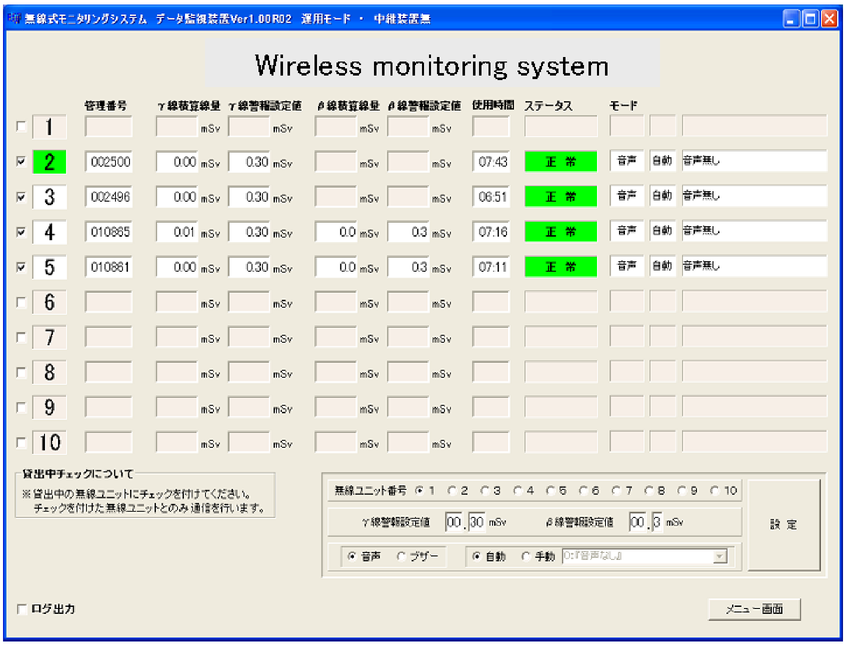
3.3 Relay station

The relay station acquires the dose data via wireless transmission from multiple wireless attachments, and temporarily stores the dose data received. The relay station can be connected via a D-SUB connector to a PHS, to an Ethernet or to a data processing unit, and uses these communication methods to transmit the dose data to the data processing unit.

3.4 Data processing unit

The data processing unit is capable of displaying the cumulative dose values of the personal dosemeters and also displaying the status of the wireless attachment. Figure 4 shows an example of the operating mode screen for the case in which ten wireless attachments are used.

Figure 4 Example display screen of data processing unit



4. Conclusion

A new personal dose monitoring system to monitor the personal dose in real time for each worker working in a radiation controlled area could be realized by using the wireless communication system in good reliability. In the future, Fuji Electric systems Co. intends to deploy this system both domestically and abroad, and to continue to supply technologically advanced and highly reliable products.

References

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