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Centralized Environmental Radiation Monitoring System in JAERI

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Abstract

Japan Atomic Energy Research Institute (JAERI) has continued the environmental radiation background survey and monitoring to ensure the safety of the peoples around the institute since one year before the first criticality of JRR-1 (Japan Research Reactor No.1) in August 1957. Air absorbed doses from β and γ radiation, α and β radioactivity in air and the radioactivities in environmental samples were the monitoring items. For the monitoring of β and γ radiation and α and β radioactivity in air, monitoring station and the centralized automatic environmental radiation monitoring system applying a computer were established as a new challenging monitoring system for nuclear facility, which was the first one not only in Japan but also in the world in 1960 and since then the system has been renewed two times (in 1973 and 1988) by introducing the latest technology in the fields of radiation detection and computer control at each stage. Present system renewed in 1988 was designed to prevent the interruption of monitoring due to computer troubles, communication troubles and power failures especially an instant voltage drop arisen from thunder by reflecting the experiences through the operation and maintenance of the former system. Dual telemeters whose power is constantly supplied via batteries (capable of 10 min monitoring after power failure) are equipped in the monitoring center to cope with telemeter troubles, which has operated successfully without any suspension being attributable to the power failures and telemeter troubles.

Introduction

Japan Atomic Energy Research Institute (JAERI) started and has continued the environmental radiation background survey and monitoring to ensure the safety of the peoples around the institute since one year before the first criticality of JRR-1 (Japan Research Reactor No.1) in August 1957. The environmental radiation monitoring program carried out presently at the Tokai Research Establishment of JAERI is shown in Table 1.

The centralized automatic environmental radiation monitoring system (hereinafter called "EMS") applying a computer was established as a new challenging monitoring system for nuclear facility, which was the first one not only in Japan but also in the world in 1960 and since then the system has been renewed two times (in 1973 and 1988) by introducing the latest technology in the fields of radiation detection and computer control at each stage.

By the relay type computer and wireless telemeter, the initial system monitored total 32 items from 8 monitoring stations installed around the Tokai establishment of JAERI [at each station, 4 items such as dose rates from γ and β ray and α-ray and β-ray concentrations in atmospheric dust were measured; hereinafter called "Monitoring Station (MS)"]. This monitoring system monitored the data every 10 minutes under the 24-hour system, which caused the consumption and melting of the contact points of the relay used in the computer and telemeter. Furthermore, failures of radio tubes used in the radiation measuring instrument and in the wireless installation also occurred frequently, so that the repair and the preventive maintenance were major daily tasks at that time[1].

In 1962, a new concept emergency γ-ray monitoring system was begun to construct (hereinafter called "monitoring post"[MP]). Pulses from each GM tube detector at 16 monitoring posts were directly transmitted by each high- frequency coaxial cable to the monitoring center and when the level of γ-ray dose rate at any point exceed previously defined abnormal level (50 μR/h), every analogue recorders connected to 16 monitoring posts are begun to record the dose rate automatically (in normal situation no data are recorded) independent of EMS. By September 1965, nine MPs were installed around the site boundary and seven off site. The first comprehensive renewal was carried out from the year 1973 and was completed in 1978. The purposes of the renewal are focused on the rapid and

synthetic judgement and estimation of the environmental impacts caused by radiation and radioactive materials generated and released due to the normal and abnormal operation of the facilities by centralizing the data hitherto separately measured at MS, MP, meteorological station [MES] and drainage monitoring station [DMS]. NTT's [Nippon Telegram & Telephone Cooperation], dedicated telephone lines are used for the data transmission of MP, MES and DMS and wireless installations are used for that of MS. High-sensitivity γ-ray detectors with DBM[1][2] were used in the monitoring posts, making it possible to measure and evaluate the low-level γ-ray dose rates in normal operation of facility[3].

New EMS has been operating since April 1988 after two years construction of computer system and telemeter unit. In the following chapters, the renewed EMS is described[4].

Outline of the System

Basic ideas concerning the monitoring and the design of the system are not different from those renewed in 1973. However, emphasis was placed on full utilization of computer and minimum suspension of the monitoring. Following are the main improvements made.

Table 1 Environmental Radiation Monitoring Program In JAERI

Monitoring items	Monitoring point	Monitoring frequencies	Methods of measurement, etc.
γ-ray dose (air absorbed dose rate)	On site 11 Off site 7	Continuously	2"ϕ ×2"NaI(Tl) with DBM(*) module to flatten the energy dependency Monitoring post(14), Monitoring station(4)
Integral dose	On site 13 Off site 20	Quarterly	TLD($CaSO_4$: Tm) Integral dose in 3 months
Dose survey Stationary	19	Twice a year	5"ϕ Spherical NaI(Tl) with DBM(*) module γ-ray dose rate, γ-ray spectrometry, Monitoring car
Mobile	Around 20km	Once a year	5"ϕ Spherical NaI(Tl) with DBM module γ-ray dose rate, Monitoring car
Land samples Radioactivities in air dust	On site 2 Off site 2	Continuously	Gross β radioactivities sampled on the fixed filter paper are monitored by GM tube Monitoring station (4)
Radionuclides in air dust	On site 2 Off site 2	Monthly	Fixed filter papers at monitoring station are dismounted at the end of month and analyzed by γ-ray spectrum in laboratory
Soil	5	Twice a year	Gross β, γ-ray spectrometry
Agricultural products	3 species	At the time of harvest	Gross β, γ-ray spectrometry, Chemical analysis Spinach, Polished rice, Sweet potato
Grass, Milk	1	Twice a year	Gross β, γ-ray spectrometry
Drinking water	7	Twice a year	Gross β, Tritium analysis
River water	2(Kuji river)	Twice a year	Gross β, Tritium analysis
Underground water	Off site 5	Twice a year	γ-ray spectrometry, Tritium analysis
Fall out	On site 1	Monthly	Gross β, γ-ray spectrometry
Rain water	On site 1	At the time of rainfall	Gross β
Pine needle	On site 1	Twice a year	Gross β, γ-ray spectrometry(Index plant)
Liquid waste Drainage concentration	No.1, No.2, drainage	Continuously	Gross β, γ-ray spectrometry(Once a week)
	No.3 drainage	Once a week	
Sand at drainage outlet	No.1, No.2, No.3 drainage	Twice a year	Gross β, γ-ray spectrometry
Sea samples Sea water and deposit	Off coast of Tokai Estab., 2 points	Quarterly	Gross β, γ-ray spectrometry, Chemical analysis
Sea plants	Off coast of Tokai Estab. 3 species	Twice a year	Gross β, γ-ray spectrometry, Chemical analysis Fishes, Seaweeds, etc
Meteorological observation	On site 1 Meteorological tower	Continuously	Wind speed, wind direction, etc (34 items)

(*) Discrimination Bias Modulation

1) The telemeter unit in the monitoring center (central telemeter) is duplicated and an uninterrupted power supply battery for ten minutes is installed in each telemeter independently.
2) The central telemeter functionates the data acquisition, monitoring and short-period data storage (Magnetic bubble memory stores the data of 6 days of 10 min. value).
3) A single computer of high performance (processing computer) is employed for data filing, statistical analysis, calculation of air absorbed doses and dose equivalents by inhalation (radioactivity concentrations in air), plotting (isopleth)/listing of calculated and measured results.
4) Information on the operational status of and radioactivity released from the major research reactors in Tokai site is collected.
5) NTT's dedicated telephone lines are used to keep high quality and reliability of the data transmission.

Monitoring Program

The central telemeter collects the counts measured at each monitoring point every 1-min interval and the counts are converted to the data of practical unit with conversion factors and the data are checked by previously defined alarm levels and abnormal levels, failure, outage etc., then the necessary outputs (sound, lamp flickering, printout) are made according to the results of the checks. After these abnormal checks, data are turned over to a data processing computer. Because the numbers of the data collected are numerous (with 30 local telemeter units; 252 elements of numeric data, 592 elements of monitoring information, and 66 elements of control output) and moreover the data collection is required to finish in short time, the communication lines are divided into three parts to collect the data systematically.

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[1] Discriminator Bias Modulation; 2"ϕ ×2"L NaI(Tl) scintillation detector with DBM method to flatten the energy dependency

Monitoring program is composed of the routine processing and emergency processing functions. Functions are shared by the central telemeter and the processing computer. A flow-chart of the environmental radiation monitoring program is shown in Fig.1.

The new EMS is designed making easy to analyze and evaluate the variations observed at the monitoring points in normal and abnormal operation of facilities comprehensively using the information of meteorology, release of radioactivities and demography to confirm and to make decision needed for the safety of public. Functions of the new EMS are shown below.

1) Data acquisition and monitoring
2) Data filing; operational status of the system, counts from monitoring points, converted data and processed data (hourly report, daily report, quarterly report, annual report, etc.)
3) Data output; above filing data on map panel, graphic display and printers with sound and lamps flickering for some specific data.
4) Calculation of internal exposure due to inhalation, γ-ray air absorbed dose rates and ground surface contamination by using the real time information on released quantities and meteorological data.
5) Emergency processing; output all data observed and to tabulate the maximum γ-ray dose rates and maximum concentrations with their appearance points.

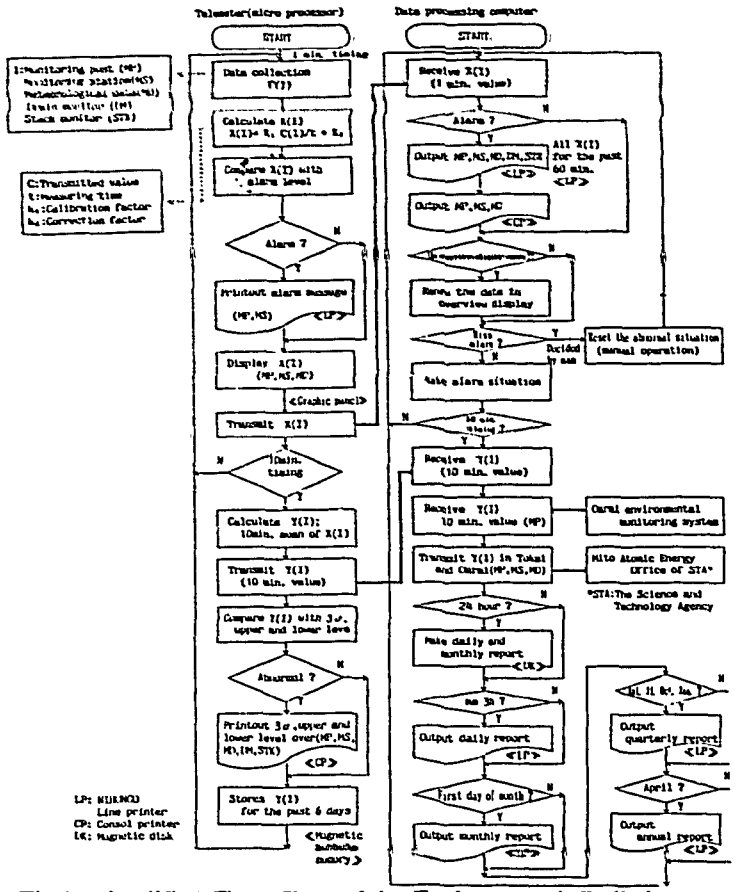

Fig.1 Simplified Flow Chart of the Environmental Radiation Monitoring Program

Composition of the EMS

Overall composition of the EMS is shown in Fig. 2.

1) Central telemeter
The duplicated central telemeter is connected with local telemeter units by NTT's dedicated lines. One unit (master) is engaged in on-line works and another unit (slave) monitors the suspension of master unit to substitute the roll of the control and monitoring. The central telemeter is also connected to a monitoring map panel and an alarm panel.
2) Local telemeters
Each local telemeter has a clock to ensure the data collection even when a command from the central telemeter is missed (the clock is free from a power failure for 48 hours by using a battery). Local telemeters start data accumulation with the clock pulse from themselves and by a calling from the central telemeter at one-minute intervals, the data accumulated are transmitted to the central telemeter. The operational status (abnormal situation of the local system) are also transmitted to the central telemeter (status is checked every second and any abnormal event thus disclosed is cheeped for a duration up to the termination of the current minute).
3) Data processing unit
For the data processing unit, super minicomputer FACOM S-3300 (memory ; 8MB) is employed.

As its peripheral equipment, there are a magnetic disk unit, a magnetic tape unit, a display unit, a personal computer (use as a Nihongo (Japanese language) display), a Nihongo line printer and a graphic display. The data processing unit (computer) is connected with a main flame computer in the computer center of Tokai Establishment for the purpose of another precise analytical evaluation of the monitoring data.

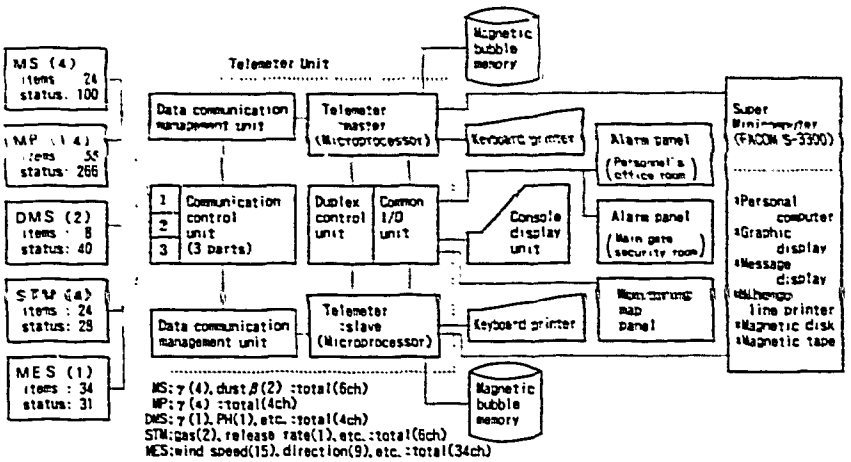

Fig.2 Composition of the Environmental Radiation Monitoring System

Conclusion

Duplicated central telemeter independently supplied by batteries for the provision of power suspension has been operated successfully without any troubles being attributable to the power failures and telemeter troubles until now. γ-ray exposure dose rates obtained by the system were used successfully for the verification study[3] of the models used in the EMS and recommended by the Guide[5] to estimate the external exposure from plume.

Although the differences of stand point between operator and local government result in the deference of items and points in the environmental monitoring program, basic concepts of EMS are extensively applied in the centralized environmental monitoring systems of other operators and local governments in Japan.

An outstanding feature of the system differing from other periodical environmental monitoring practices such as the measurement of γ-ray dose rate by monitoring car, measurement of radioactivities in environmental sample is that the system is operated under the around-the-clock system. The system is composed of numerous components such as the central monitoring equipment, fixed measuring stations, data transmission system etc., so that the entire system costs a great deal comparing the periodical monitoring. However, the monitoring system has played an important role with relation to the public acceptance for the development of nuclear energy, because it continuously monitors the environmental radiations and radioactivities in normal operation of such facilities and the results are directly shown to the public (mainly at the local government). Subsequent to the TMI-2 reactor accident, importance of the automatic centralized monitoring system has been recognized in the respect that it can produce reliable information on the environmental radiation for the decision making in emergency situation.

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