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CENTRALIZED ENVIRONMENTAL RADIATION MONITORING SYSTEM IN JAERI

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日本原子力研究所
Japan Atomic Energy Research Institute

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Centralized Environmental Radiation Monitoring System in JAERI

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Japan Atomic Energy Research Institute (JAERI) started and has continued the radiation background survey and environmental radiation monitoring to ensure the safety of the residents around the Institute since one year before the first criticality of JRR-1 (Japan Research Reactor No.1) in August 1957. The monitoring items were air absorbed doses from β and γ radiations, α and β radioactivities in air and radioactivities in environmental samples. For the monitoring of β and γ radiations and α and β radioactivities in air, the centralized automatic environmental radiation monitoring system (EMS) applying a computer with monitoring stations (MS) was established as a new challenging monitoring system for nuclear facilities, 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 technologies in the fields of radiation detection and computer control at each stage. In 1962, a new concept emergency environmental γ-ray monitoring system (MP) was begun to construct and completed in 1965 independent of EMS. The first renewal of the EMS was carried out by focusing on the rapid and synthetic judgement and estimation of the environmental impacts caused by radiation and radioactive materials due to the operation of nuclear facilities by centralizing the data measured at MS, MP, a meteorological station, stack monitors and drainage monitoring stations under the control of computer, whose concept has been widely applied for the similar system of the nuclear power plants and local governments in Japan.

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 caused by 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.

Keywords: Environment, Radiation, Monitoring, Centralized System, Monitoring Station, Monitoring Post, Concentration, Telemeter, Absorbed Dose, Dose Estimation, Monitoring Program

JAERI-M 93-036

東海研究所における環境放射線監視システム

日本原子力研究所東海研究所保健物理部
片桐　浩・小林　秀雄

（1993年1月29日受理）

日本原子力研究所東海研究所では，周辺公衆の安全を確保することを目的として，1957年8月ＪＲＲ－１の初臨界の１年前から施設稼働前放射線バックグラウンドサーベイと環境放射線モニタリングを開始して以来，今日まで，種々の環境モニタリングを継続してきた。当初の測定項目は，空間のγ及びβ線量率，大気塵埃中のα線，β線濃度，環境試料中放射能濃度であった。空間のγ及びβ線量率，大気塵埃中のα線，β線濃度の監視は，計算機による自動集中監視モニタリングシステムにより，1960年に原子力機関としては国内はもとより世界的にも新しい試みとして実用化された（モニタリングステーション）。一方，1962年からは，計算機によらず，直接中央に伝送し集中監視する非常用モニターの建設を開始し，1965年に完成した（モニタリングポスト）。その後，このシステムは，放射線測定器，計算機とその周辺機器等に関する最新の技術を導入して，２回の更新を行ってきた。1973年の更新にあたっては，モニタリングステーション，モニタリングポスト，気象局，排気モニタ，排水モニタのデータを計算機により集中化し，原子力施設から環境への影響を迅速かつ総合的に評価することに主点が置かれた。このシステムの考え方は，原子力発電所等の施設者や自治体でも広く活用されている。1988年に更新を行った現システムは，従来の監視システムの運転経験を生かして，計算機の故障，データ伝送装置の故障，停電，特に雷による瞬断等の対策を計り，監視の中断を可能な限り少なくすることに重点を置いた。瞬断や伝送装置の故障等を防ぐために，中央監視室に無停電電源（バッテリーにより10分間電源供給）による二重化されたテレメータが設置されている。

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Contents

目　　次

1. Introduction (Circumstances)

Japan Atomic Energy Research Institute (JAERI) started and has continued the radiation background survey and environmental radiation monitoring to ensure the safety of the residents 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 JAERI's Tokai Research Establishment 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 facilities, 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 newest technologies 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 points installed around the Tokai establishment of JAERI [at each point, 4 items such as γ-ray and β-ray dose rates and α-ray and β-ray concentrations in atmospheric dust were measured; hereinafter called "Monitoring Station (MS)"]. This monitoring system acquired and 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 preventive maintenance were major daily tasks at that time. On the basis of investigation for the causes of failures, etc., a modification on a large scale was thus made in 1962, such as the replacement of the relays in troubled circuits with No.70 relay applied in a telephone switchboard as a high reliability one (as the result, the number of failures in a month reduced from about 60 to 10)[1].

In 1962, an emergency γ-ray monitoring system based on a new concept was begun to construct (hereinafter called "monitoring post" [MP]). Pulses from each GM tube detector(side window type detector) at the monitoring posts were directly transmitted by each high-frequency coaxial cable to a monitoring center and when the γ-ray dose rate level at any point exceed previously defined abnormal level (50 μR/h), every analogue recorders connected to 16 monitoring posts begin to record the dose rate automatically (below the level no data are recorded) independent of EMS. By September 1965, nine monitoring posts were installed around the site at its

boundary and seven off site. Subsequently up to the renewal in 1973,

Table 1 Environmental Radiation Monitoring Program in Tokai Estb.

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	9	Twice a year	Gross β, γ-ray spectrometry
Agricaltural 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 drainages 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

continuous radiation monitoring at fixed observation points was made by the above-described two systems, to cope with any failures. The first comprehensive renewal was carried out from the year 1973 and was completed in 1978. The renewal was carried out by focusing on the rapid and synthetic judgement and estimation of the environmental effects caused by

radiation and radioactive materials generated and released due to the normal and abnormal operation of the facilities by centralizing the data separately measured at the monitoring stations, monitoring posts, meteorological station and drainage monitoring stations. Principal features of the renewal are as follows;

1) To centralize the data separately measured hitherto at the monitoring stations (4 stations, other 4 were abolished with the completion of the monitoring posts), the monitoring posts (14 posts, other two off site posts were abolished and rearranged the monitoring points due to the improvement in sensitivity by using the NaI(Tl) scintillation detector with DBM [1]), the meteorological station (1 station, with 14 elements) and the drainage monitoring stations (2 stations, with 4 elements) by the telemeter using NTT's dedicated telephone lines and partly also the wireless installations. Figure 1 shows the monitoring points centralized into new EMS.

2) To avoid the lack of the data by noise, transmission of all monitoring data were digitalized. To keep high quality and reliability of the data and to make the maintenance of data transmission line easier, NTT's dedicated telephone lines were adopted for the data communication of the EMS. (The data from the monitoring posts had been influenced by the noises of thunders and the cables were often damaged by lightning and some construction work. Being the special cables, their restoration took considerable time.)

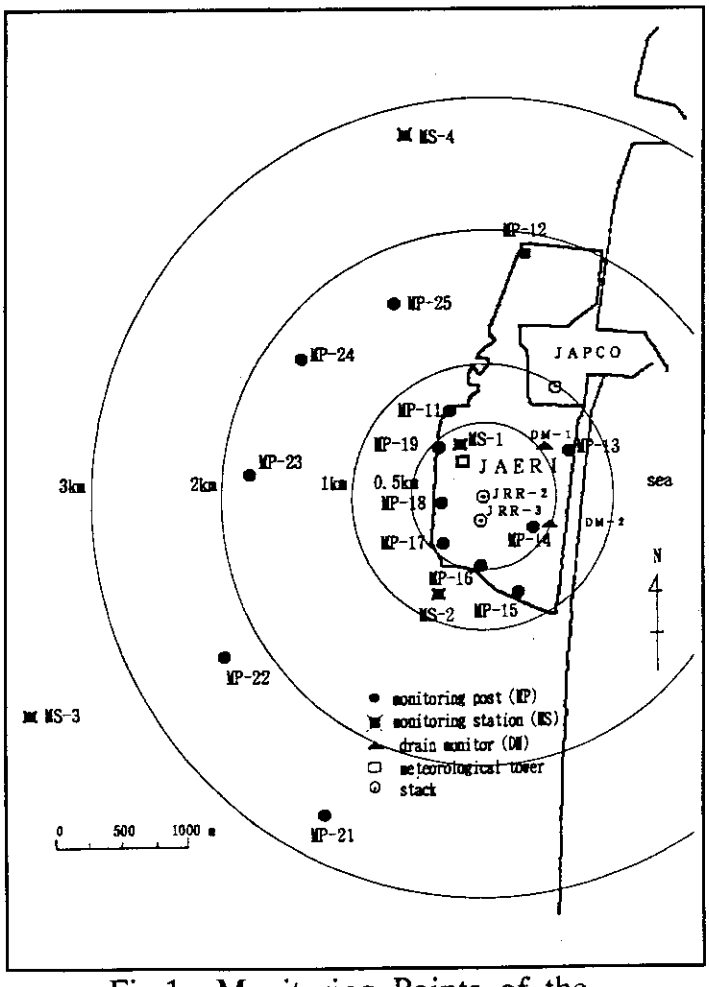

Fig.1 Monitoring Points of the Environmental Radiation Monitoring System

3) To facilitate the evaluation of the γ-ray dose rates variation observed (rise), the function to predict the γ-ray dose rates at the monitoring points caused by the radioactive release from the facilities was added by collecting the meteorological data in real time (the γ- ray dose rates were calculated for unit release rate because the release data were not input).

4) To make various
predictions rapidly at the time of emergency, all the monitoring data of the past one hour were printed out automatically at two minutes interval when the alarm level was exceeded. (The calculation of the γ- ray dose rates in 3) above was also executed at every two minutes.)

5) The computer system was duplicated in case of computer trouble or maintenance. Following an outage, the computers were automatically recovered. (Clocks did not suffer a power suspension, due to the usage of a battery.)

6) High-sensitive γ-ray detectors with DBM[1] were used in the monitoring posts, making it possible to measure and evaluate the low-level γ-ray dose rates in normal operation of the facilities. (Refer Chapter 5. Results of observation.)

The 2nd renewal was started in 1986. New EMS has been operating since April 1988 when the data transmission unit (the telemeter unit in the monitoring center and at the monitoring points in the environment) and a processing system were partly finished after 2 years construction in April 1988, although detectors at MS, MP were renewed in May 1989. In the following chapters, the renewed, environmental radiation monitoring system is described.

2. Outline of the System

Basic ideas concerning the monitoring and the design are not different from those renewed in 1973. However, emphasis was placed on full

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[1] 2"ϕ ×2"l NaI(Tl) scintillation detector with DBM method to flatten the energy dependency

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utilization of a computer and minimum suspension of the monitoring. Followings are the main improvements made.

1) The telemeter unit in the monitoring center is duplicated and an uninterrupted power supply battery for ten minutes is installed.

2) The telemeter unit in the monitoring center executes the data acquisition, monitoring and short period data storage (the capacity of the 10–minute value data for 6 days).

3) A single computer of high performance (processing computer) is employed for data filing, statistical analysis, calculation of radioactivity concentrations in air and doses, plotting/listing of various data and processing results.

4) Information on the operation of and radioactivity release from major facilities (research reactors etc.)in Tokai site is collected.

5) NTT's specific telephone lines are used for the data communication.

2.1 Monitoring Program

The items monitored by the EMS are tabulated in Table 2. The telemeter unit in the monitoring center 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 on previously defined alarm levels and abnormal levels, failure, outage etc., then the necessary outputs (sound, light, printout) are made according to the results of the checks. After these abnormal checks, the data are turned over to a data processing computer.

Monitoring program is composed of the routine processing and emergency processing functions. Functions are shared by the telemeter unit in the monitoring center and the processing computer. A flow chart of the environmental radiation monitoring program is shown in Fig.2.

2.2 Functions

The new EMS is designed to analyze and evaluate the variations observed at the monitoring points in normal and abnormal operation of

Table 2 Monitoring Items and the Method of Measurement Used in the Environmental Radiation Monitoring System

(1/3)

Items	Data name	Data type*	Methods of measurement
Monitoring post (MP) 14 ch(spare 1ch)	Low level γ dose rate	D	2"φ×2" NaI(Tl) with DBM module to flatten the energy dependency
	Hi level γ dose rate	D	2"φ×2" NaI(Tl) with Pb filter to flatten the energy dependency, wide range type (current method), (6 ch)
	S C A 1	D	Counting rate using Single Channel Analyzer (measuring the natural dose rate)
	S C A 2	D	Above same
Monitoring station (MS) 4 ch(spare 1ch)	Air concentration	D	Gross β radioactivities on the fixed filter paper in dust sampler
	Air flow rate	A	Air flow rate of dust sampler(≒100 l/m)
	Reserve 1	D	TTL pulse data
	Reserve 2	A	Analog data
Drain monitor 2 ch(spare 1ch)	γ concentration	D	γ radioactivities in drainage water
	Water level	A	Drainage water volume per min. (conversion of water level into water volume)
	P H	A	PH in drainage water
	Temperature	A	Temperature in drainage water
	Reserve 1	D	TTL pulse data
	Reserve 2	A	Analog data
Stack monitor 4 ch(spare 2ch)	Stack gases	A	Gaseous concentration in stack (normal gases monitor)
	Emergency gases	A	Gaseous concentration in stack (emergency gases monitor)
	Energy	A	Average energy of nuclides (above same)
	Release rate	A	Release rate of nuclides from stack
	Power level	A	Operation power level of the reactor
	Reserve	A	Analog data

* D:Digital type, A:Analog type

(2/3)

Items	Data name	Data type	Methods of measurement
Meteorological observation 1 ch	Wind direction 10m	A	Propeller anemometer, Tower
	Wind speed 10m	D	〃
	Wind direction 20m	A	〃
	Wind speed 20m	D	〃
	Wind direction 40m	A	〃
	Wind speed 40m	D	〃
	Wind direction 10m	A	Supersonic anemometer, Tower
	Wind direction variation 10m	A	〃
	Horizontal wind speed 10m	A	〃
	Horizontal wind speed variation 10m	A	〃
	Vertical wind speed 10m	A	〃
	Vertical wind speed variation 10m	A	〃
	Wind direction 20m	A	〃
	Wind direction variation 20m	A	〃
	Horizontal wind speed 20m	A	〃
	Horizontal wind speed variation 20m	A	〃
	Vertical wind speed 20m	A	〃
	Vertical wind speed variation 20m	A	〃
	Wind direction 40m	A	〃
	Wind direction variation 40m	A	〃
	Horizontal wind speed 40m	A	〃
	Horizontal wind speed variation 40m	A	〃
	Vertical wind speed 40m	A	〃
	Vertical wind speed variation 40m	A	〃

(3/3)

Items	Data name	Data type	Methods of measurement
Meteorological observation 1 ch	Temperature 1.5m	A	On the measuring field
	Temperature gradient 1	A	△T (10m － 1.5m), Tower
	Temperature gradient 2	A	△T (20m － 1.5m), Tower
	Temperature gradient 3	A	△T (40m － 1.5m), Tower
	Atmospheric pressure	A	Measuring house
	Solar radiation	A	On the roof of measuring house
	Net radiation	A	On the measuring field
	Dew-point temperature	A	〃
	Precipitation	D	〃
	Fog sensitivity	A	〃
	Reserve (1～4)	A	Analog data

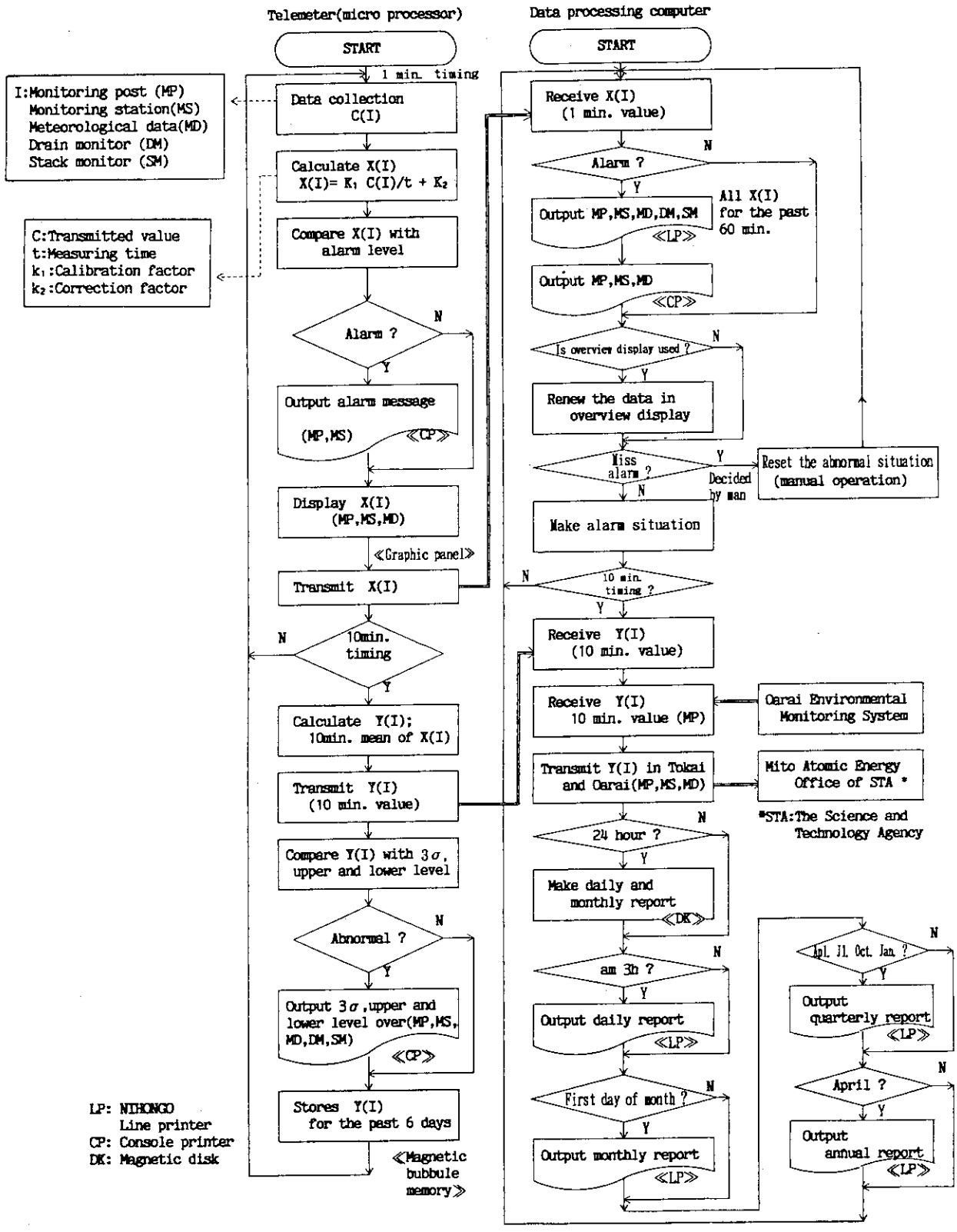

Fig.2 Simplified Flow Chart of the Environmental Radiation Monitoring Program

facilities by centralizing the environmental radiation monitoring data for producing the information to keep the safety of the public. Functions of the new EMS are shown below.

1) Data collection and monitoring
   a) To collect the data at one-minute interval
   b) To check the performance of the transmission and measuring systems to identify any failure of the system
   c) To convert the counts (measured data) to practical units
   d) To detect the abnormal radiation data to raise an alarm and to output the data concerned

2) Data filing
   To file operational status of the system, counts (measured data) from the monitoring points, converted data and processed data (hourly report,daily report, quarterly report, annual report, etc.)

3) Data process and output
   To output operational status, alarms and measured counts (1-min measured data, 10-min values, hourly report, daily report, monthly report etc.) by sound and lamps flickering, on a monitoring map panel (1-min value of γ-ray dose rate, meteorological data) and graphic display (trends, concentration and γ-ray dose rate distribution)

4) Calculation of airborne concentrations and γ-ray dose rates from released quantities
   a) To calculate the γ-ray rates at the points of monitoring posts and monitoring stations
   b) To calculate airborne concentrations, internal exposure due to inhalation and external exposure from plume and ground surface contamination at any given points for making isopleth charts using the released radioactivities from stacks and the meteorological data obtained in real time

5) Emergency processing
   To output all the data observed and to tabulate the maximum γ-ray dose rates and maximum concentrations with their appearance points.

6) Tables for the management of the system
   To manage the system, following tables are prepared;

Conversion factors
Values to check the abnormal situation
Alarm level, mean＋3 σ (σ :standard division), operational status such as adjustment, temperature abnormality, outage, etc.
Records of manual data update (correction)

7) Auxiliary functions
To collect the data observed by other systems (for example, carborne survey data by a monitoring car, in－situ spectrum data, TLD data etc.) and to execute the batch process－programs (for example, simplified SPEEDI (System for Prediction of Environmental Emergency Information) [2,3]).

3. System Construction and Monitoring Program

3.1 Features of the System

From the experience so far, the followings were considered in system design.

1) Duplication of the telemeter unit
EMS is expected to operate continuously free from any trouble. For that, the duplication of all components constituting the system is desirable. However the duplication of such, including radiation measuring units, local telemeter units and a computer is almost impossible due to costs. There is also limitation in power supplies and floor space.
In this new EMS, the telemeter unit in the monitoring center (hereinafter called "central telemeter"), which is the most important component from the view point of minimizing the lack of the data, is duplicated. And further, this duplicated central telemeter is provided with an auxiliary battery power supply for 10 minutes and a backup memory to prevent the lack of measured data at the time of power supply breakdown and computer maintenance.

2) Sharing the functions with telemeter and processing computer
Environmental radiation monitoring routine is shared with the central telemeter for data collection/monitoring and with the processing computer for data management and analysis. On－line works with relatively little man－machine interface (such as data collection, conversion to practical units and abnormalities check) are thus done by the telemeter unit

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(actually by a microprocessor built in telemeter unit). And, major management works, including data output, statistical processing, listing and plotting are done by the processing computer. Such leads to efficient operation of the system.

3.2 Composition of the EMS

Overall composition of the EMS is shown in Fig. 3.

1) Central telemeter
The central telemeter is connected with the local telemeter units by NTT's dedicated lines. As already described, the central telemeter is duplicated. That is, one is the control unit (master) doing on－line works and another is the back－up unit (slave) monitoring the control unit for suspension and substituting the roll of the control unit in case of suspension. The central telemeter is also connected to the monitoring map panel and the 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). The 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 items of both observation data (see Table 2) and the operational status transmitted from the local telemeters are shown in Table 3 (operational 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, a 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 large computer (FACOM－380) in the Information Center of Tokai Establishment for the purpose of another precise analytical evaluation of the monitoring data.

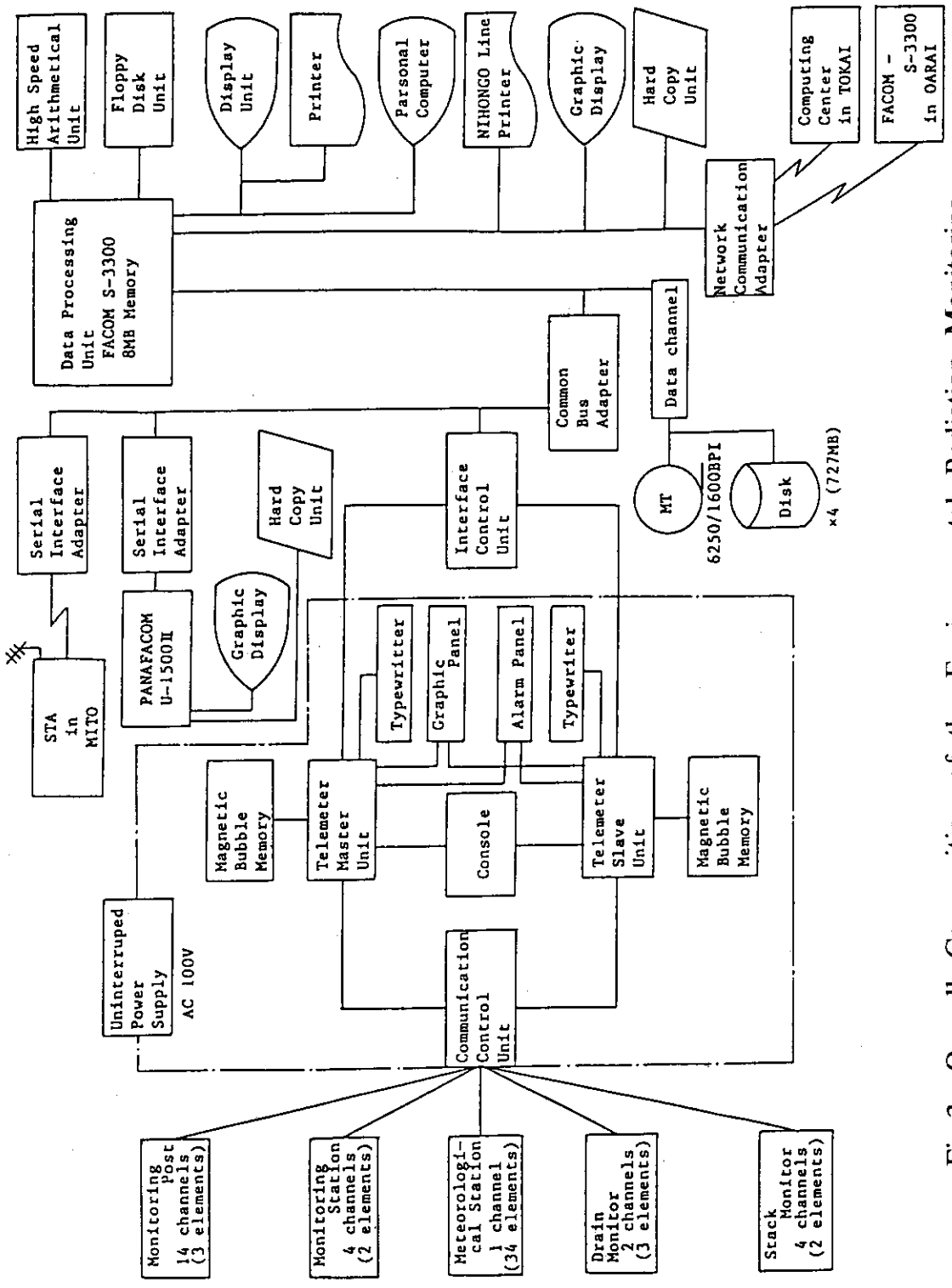

Fig.3 Overall Composition of the Environmental Radiation Monitoring System

Table 3 Operational Status of Each Local Telemeter

Items	Operational status	Note
Monitoring post(MP) Monitoring station(MS)	Power supply failure	
	Initialization MPE	Detection of memory parity error
	OVT	Detection of over time
	Clock abnormality	
	I/O error	
	Compartment door open	
	Air conditioner abnormality	
	Indoor temperature abnormality	
	Temperature abnormality 1	Surface of the detector
	Temperature abnormality 2	〃
	Temperature abnormality 3	〃
	Dust sampler pump stop	
	Breakage of dust sampler filter paper	
	State of filter paper moving on dust sampler	
	Printer error	
	Low level γ monitor adjustment	
	Hi level γ monitor adjustment	
	S C A 1 adjustment	
	S C A 2 adjustment	
	Dust monitor adjustment	
	Dust sampler start signal adjustment	Remote control from master telemeter
	Dust sampler stop signal adjustment	Remote control from master telemeter
	Remote control signal adjustment	
	Telemeter unit adjustment	
Drain monitor	Power supply failure	
	Initialization MPE	Detection of memory parity error
	OVT	Detection of over time
	Clock abnormality	
	I/O error	
	Compartment door open	
	Air conditioner abnormality	
	Indoor temperature abnormality	
	Temperature abnormality	Surface of the detector
	Water pump abnormality	
	Water pump stop	
	Radiation monitor adjustment	
	Water level detector adjustment	
	P H meter adjustment	
	Temperature detector adjustment	
	Water pump start control	Remote control from master telemeter
	Water pump stop control	Remote control from master telemeter
	Telemeter unit adjustment	
Stack monitor	Power supply failure	
	Initialization MPE	Detection of memory parity error
	OVT	Detection of over time
	Clock abnormality	
	I/O error	
	Reactor operational state	The signal concerned operation of of the reactor
Meteorological observation	Power supply failure	
	Initialization MPE	Detection of memory parity error
	OVT	Detection of over time
	Clock abnormality	
	I/O error adjustment	
	Indoor temperature abnormality	
	Wind direction of propeller anemometer adjustment	10,20,40m height
	Wind speed of propeller anemometer adjustment	〃
	Wind direction of supersonic anemometer adjustment	〃
	Wind speed of supersonic anemometer adjustment	〃
	Thermometer and temperature gradients adjustment	〃
	Barometer adjustment	
	Solar radiation sensor adjustment	
	Net radiation sensor adjustment	
	Dew point sensor adjustment	
	Precipitation sensor adjustment	
	Fog sensor adjustment	
	Telemeter unit adjustment	

The data processing unit also transmits specific data monitored by EMS with those monitored and transmitted by the NTT's specific telephone line by the Environmental Monitoring System of Oarai Establishment (Oarai site) to Mito Atomic Energy Office of the Science and Technology Agency in Mito City by a wireless telemeter.

3.3 Monitoring Program

The environmental radiation monitoring program is shared its role by the central telemeter, which is assigned for the on－line routines such as real－time data collection and monitoring, and the data processing unit, which is assigned for the batch processing such as statistical analysis, dose and concentration calculation and making reports. In the following, the monitoring program by the central telemeter unit and data processing unit is described.

3.3.1 Monitoring Procedures of the Central Telemeter

The monitoring procedures of the central telemeter constructed with firmware are as follows (see Fig.4);

a) Data collection from the local telemeter
b) Conversion of collected data to practical units
c) Data transmission to the data processing unit
d) Alarm outputs
e) Data display on the monitoring map panel
f) Outputs of the γ－ray dose rates and meteorological data to a keyboard printer
g) Data backup

Because the number of the data collected is 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 a short time, the communication lines are divided into three parts to collect the data systematically.

A recalling to a no－response local unit is made to a maximum of two times (up to three callings, including the initial calling), and this recalling is made only after all callings to the local units in this system have been finished. This data recalling is then stopped 30 seconds after the start of

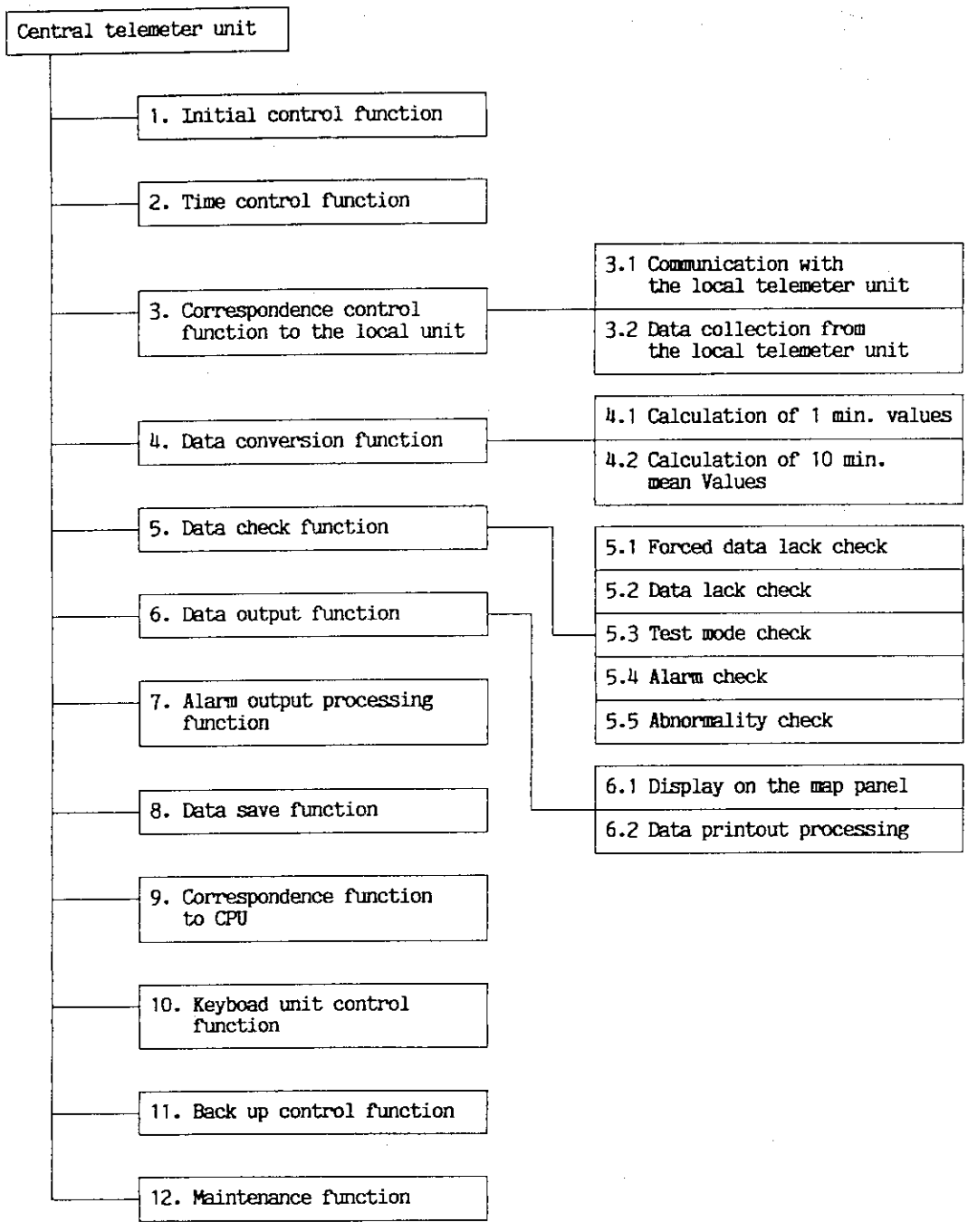

Fig.4 Monitoring Program of Central Telemeter

collection and subsequently the following processes are followed;

a) Conversion to practical units
b) Data check and message printout
c) The 10-min value calculation
d) Data transmission to the data processing unit, etc.

Followings are main function of the central telemeter unit.

1) Time control

The central telemeter unit renews the "system time" by reading the clock installed in it at every 1 sec. To terminate the required monitoring processes within one minute, following procedures are executed.

a) Communication management (Open the line during 20 ～ 55 sec. in each minute for aural communication to support the maintenance).
b) Time check procedure for the slave telemeter (at 30 sec. in each minute).
c) Starting of data collection process (at 0 sec. in each minute).
d) Forced termination procedure of data collection (at 30 sec. in each minute).
e) Forced termination procedure of data printout (at 55 sec. in each minute).

2) Data collection function

The central telemeter unit collects the data stored in the local telemeter units by the polling procedure at every one minute. Every ten minutes, a time collection command ordering the clock in the local telemeter units to synchronize with the time of central telemeter is transmitted to all the local telemeters. During data collection, aural communication is prohibited.

3) Data compilation function

The data (counts) collected from the local telemeters are converted to practical units which are defined as the 1-min value data and used for the precise analysis of the trend especially in case of abnormal situation. At the time of exact very ten minutes, 10-min data are generated on the basis of the 1-min value data in the past ten minutes as the basic data of the EMS.

4) Data check function

The processes below are executed every one minute referring to the data transmitted from local telemeters. If there occur something unusual situations shown in a)～e), messages are written on the printer and lamp flickering and buzzer sounding are triggered.

a) Abnormal status at the monitoring points (compartments) (indoor temperature abnormality, compartment door open, power failure etc.)
b) Status of equipment (under maintenance operation, equipment

abnormality, dust sampling filter paper abnormality, etc.)

c) Management of the labeled data which are used as references due to the failures of some components of the system; e.g. malfunction of the detector, high voltage power supply, dust sampler etc. (abnormal checks and data storage as basic data are not curried out)

d) Exceed or under the lower limit, mean+3σ, the upper limit and alarm level values previously given as reference values for monitoring.

e) Data validity check.

5) Data output function

The 1－min values of the following items are displayed on the data display panel (monitoring map panel).

a) γ－ray dose rates at the monitoring posts (14 points).

b) γ－ray dose rates at the monitoring stations (4 points).

c) Wind direction and wind speed with their observation height and atmospheric stability.

d) Operational status of reactor facilities.

6) Alarm output function

When some unusual situations are detected by the above 4) (Data check function), messages corresponded to each abnormality are outputted on the printer and also lamp flickering and buzzer sounding are triggered as shown in the followings.

a) The message outputs to the keyboards printer.

b) Lamp flickering and buzzer sounding at the console panel in the monitoring center.

c) Lamp flickering and buzzer sounding at the personnel's office room.

d) Lamp flickering and buzzer sounding at the panel of main gate security room.

7) Data storage function

The following data are stored in the magnetic bubble memory of central telemeter.

a) The 10 min data are stored for six days (data capacity = 1792byte/time × 144 times/day × 6 days ≒ 1.5 Mbyte) in cyclic manner.

b) The 1－min value data for calculation of the 10 min data are stored (capacity:2528 byte).

c) The reference values needed for the monitoring are stored (capacity:7792 byte for 2268 elements including conversion factors, alarm values etc.).

8) Keyboard printer function

When the data of γ－ray dose rates exceed the alarm level, all the γ－ray dose rates, wind directions and wind velocities at the height of 10 m, 20 m and 40 m, atmospheric stability and precipitation are printed out every one minute on the keyboard printer. Operators can command the central and local telemeters manually to printout and/or to control the system as follow;

a) Printout the counts (unconverted data) from local the telemeters.
b) Printout the γ－ray dose rate data.
c) Printout the reference values in the central telemeter.
d) Start and stop the dust samplers at the monitoring points.
e) Start and stop water pumps at the drain monitoring stations.

9) Backup control function

The master and slave units in the central telemeter, always watch other's operational state, so that the normal operation is maintained even when either unit get out of order. All the data from the local telemeters are stored in both master and slave units at the same time under control of the master unit usually. The slave unit acquires necessary information every 5 sec. from the master unit to smoothly take over on－line works in case of troubles.

10) Automatic restarting function

Although the central telemeter unit is covered with an uninterrupted power supply up to 10 min. with a battery to provide against an outage of the commercial power supply, the telemeter unit in the monitoring center will inevitably be stopped when power suspension continues more than 10 min. Automatic restarting function is prepared to cope with the above situation. When the central telemeter unit had stopped, the following processes are continued for automatic restarting after recovering of the power supply.

a) Restarting after recovering of the power supply

Hardware checks are done and the results are retained in the memory of system－abnormality. The initialization command for the equipment connected to the central telemeter is then issued. And a message of the system starting is also printed.

b) Restarting at other times independent of recovering of the power supply
The initialization command for the equipment connected to the central telemeter is then issued. And a message of the system starting is also printed.

3.3.2 Environmental Radiation Monitoring Program of the Data Processing Unit

The monitoring program of the data processing unit (computer), as shown in Fig.5, consists of system intrinsic control program and on－line processing program etc. The language used is FORTRAN 77 supplied with NIHONGO (Japanese language). The data from the central telemeter are stored in the data file of magnetic disk unit and magnetic tape unit. Data filing scheme in the data processing unit is shown in Fig.6.

The system has two types of data files, namely on－line data file and off－line data file. The off－line data file provided as a backup is supported with the magnetic tape unit and the file is recalled from the magnetic tape unit when the data files in each magnetic disks are destroyed. Based on these data in the magnetic disks, the 1－min value data, 10－min data, 1－hr data, daily report, monthly report, etc. are obtained. A capacity of the on－line file in terms of memory size and days being able to keep the data in the file is tabulated in Table 4. Memory of about 240 Mbyte is thus provided to retain data of the 1－min value, 10－min value, 1－hr value, daily report, monthly report and annual report, and also monitoring information, status messages, counting data (counts from local telemeter) and the history of data correction for necessary periods of time. And further, there is also a capacity of about 140 Mbyte as an area for user's programming.

Environmental monitoring program of the processing computer is as follows;

1) Data collection function from the telemeter in the monitoring center
The data processing computer collects the 1－min values data and 10－min data from the central telemeter and stores in the on－line file and calculates the 1－hour data from the 10－min data and also stores in the on－line file every one hour. When the computer is resupplied with the electricity after the recovery of power suspension, the computer system is automatically started up. The computer system makes up the lacking

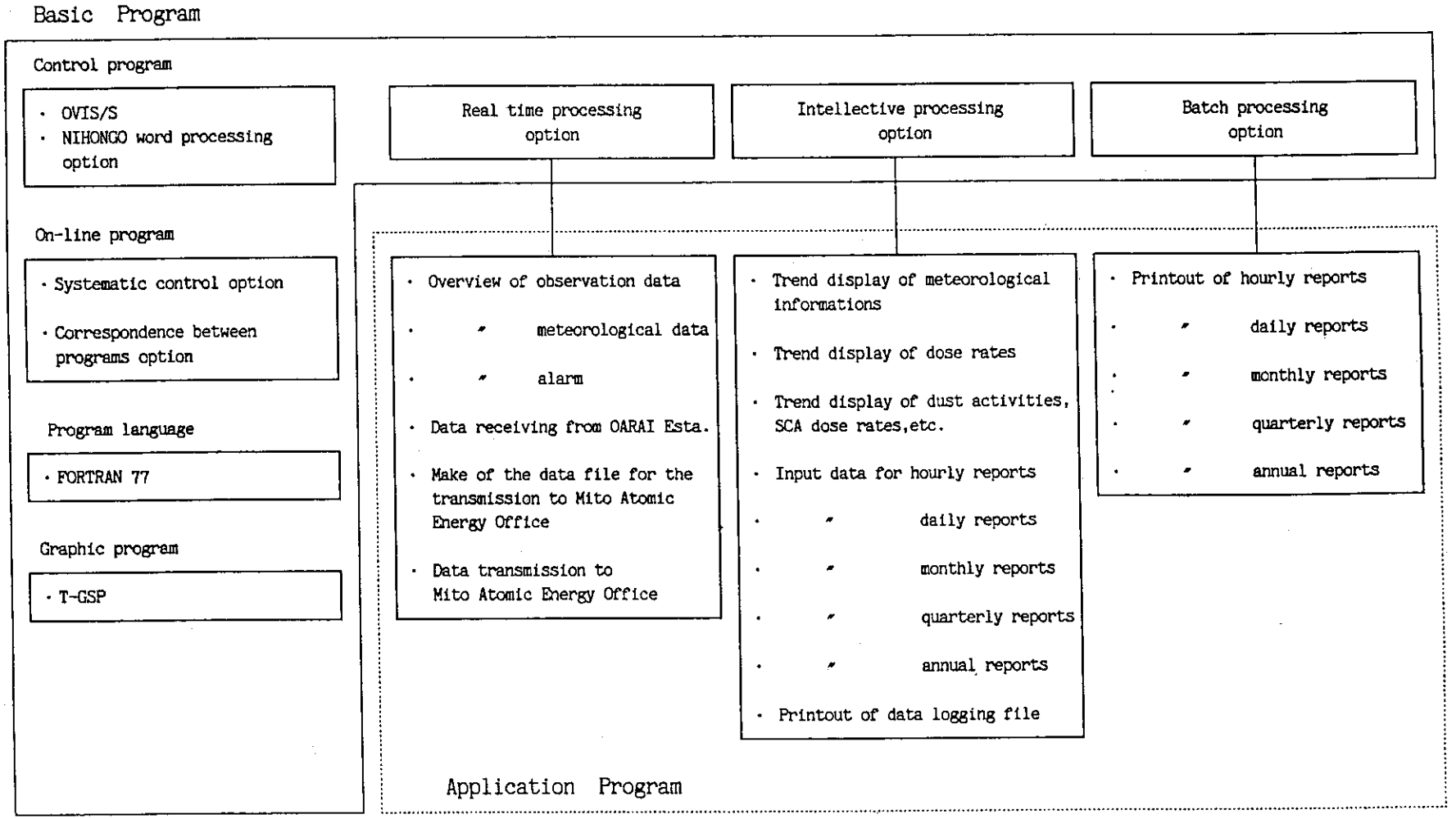

Fig.5 Environmental Monitoring Program Operated under the System Intrinsic Control Program of the Data Processing Computer

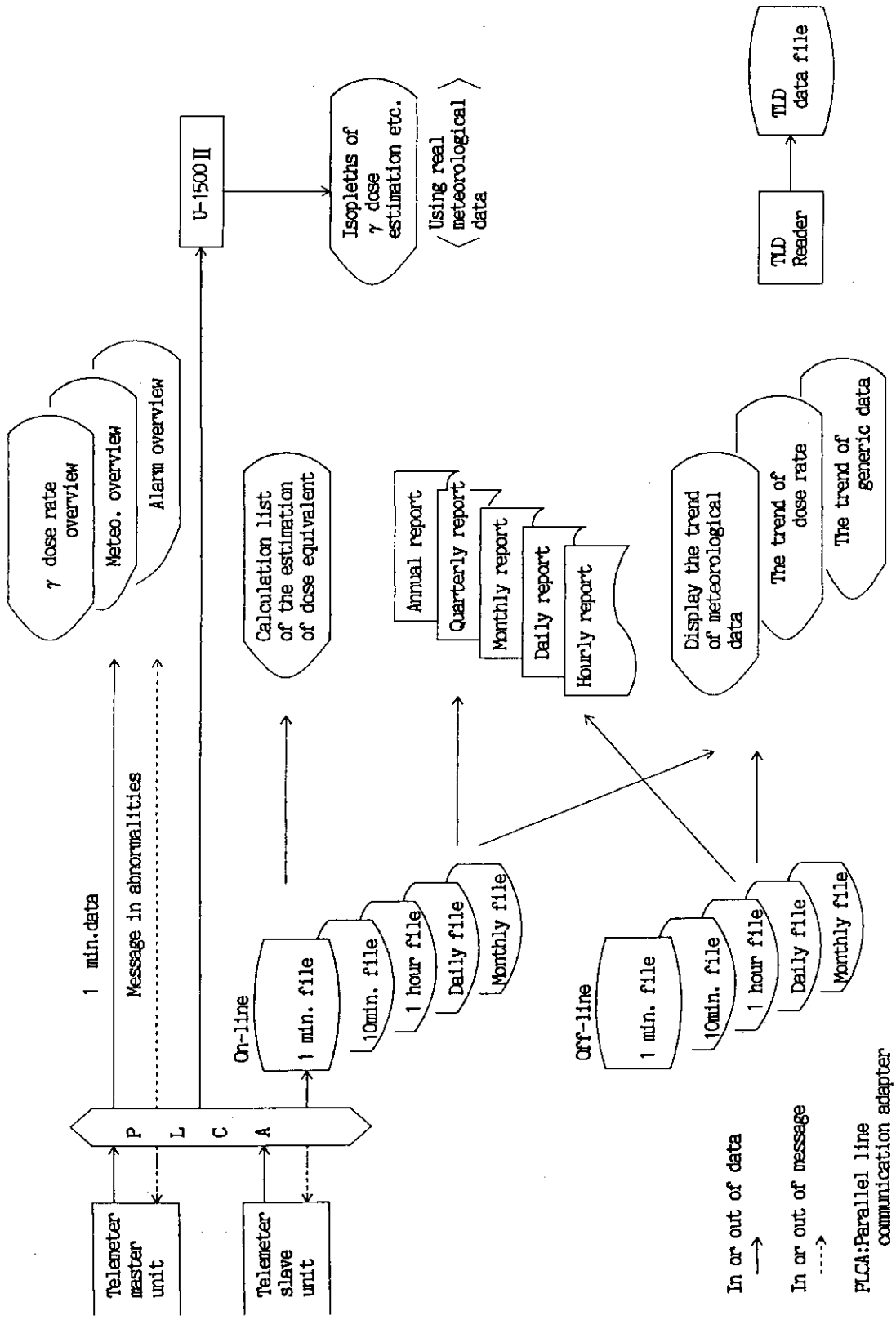

Fig.6 Data Filing Scheme in the Data Processing Computer

data during stoppage from the central telemeter unit and transfers thedata to on-line file.

Table 4 Storage Capacities of the Files in Data Processing Computer

Data file names		Storage capacities	File capacities (kB)
On line file	1 minite files	7 days	20162
	10 minite files	4 months (124 days)	35714
	1 hour files	14 months (427 days)	19058
	Daily report files	14 months (427 days)	9530
	Monthly report files	10 yeas	4356
Off line file	1 minite files	7 days	20162
	10 minite files	4 months (124 days)	35714
	1 hour files	14 months (427 days)	19058
	Daily report files	14 months (427 days)	9530
	Monthly report files	10 yeas	4359
10 minites original files		1 month (31 days)	8930
Hard ware information files		4 months (124 days)	17857
Massage data files		2000 message(1000message×2)	167
Original couting data trace files (Master unit)		1 day	18740
Original couting data trace files (Slave unit)		1 day	18740
History files of data correction		2000 data	167

2) Data check function

When collected data have exceeded an alarm level (this determination is made by the central telemeter unit), the followings are made. Output the message to the console display unit, output the 1-min values for one hour prior to the alarm generation to the line printer, real-time output of the 1-min values after the alarm generation to the console printer and also keeping the exceeded values in a message logging file of magnetic disk. Similarly, when collected data have exceeded an upper limit (lower than the alarm level), 3σ or lower limit, the data and message

are outputted and those are kept in the message logging file along with its generation time.

3) Reports printout function

Reports such as the 1-min value data, 10-min data, 1-hr data, daily report, monthly report, quarterly report and annual report are automatically and manually outputted to the line printer. The daily report can compile the table beginning and ending at the arbitrary time interval in the day.

4) Reference values (Constants) control function

Various reference values (constants) used in the central telemeter unit (abnormality criteria, measured-to-practical value conversion factors and local telemeter tables) are manually inputted from the work station. And these constants are transmitted to the telemeter master unit.

5) Data update function

The 1-min value data, 10-min data and 1-hr data can be corrected from the work station. When the 1-min value data are corrected, the 10-min data influenced are corrected. Similarly, when the 10-min data are corrected, the 1-hr value influenced is automatically corrected. The histories of such corrections can be kept in the magnetic disk file and be outputted to the line printer.

6) Data retention and restoration function

The 1-min value data, 10-min data, 1-hr data, daily report and monthly report files can be retained respectively in the magnetic tape. And, the retained tape can be restored in the off-line file of the magnetic disk.

7) Data display function

The data from monitoring posts, monitoring stations, meteorological tower, drain monitors and stack monitors are shown in the graphic display. Items of data display are as follows;

a) Measured data overview

Following data are displayed in the map and are renewed every one minute. (see Fig.7.1)

* The γ-ray dose rates at the monitoring posts and monitoring stations
* Radioactive concentrations at the drain monitoring stations

* The wind direction and wind speed with the measuring height and atmospheric stability
* Operational state of reactors etc.

b) Meteorological data overview
The 1-min value data obtained at the meteorological tower are displayed on the map panel, being renewed every one minute. (see Fig.7.2)

c) Alarm values overview
Message data transmitted from the telemeter master unit (alarm state, over-upper-limit state, etc.) are displayed and renewed when received.

d) Trend display of γ-ray dose rate
Trends of the γ-ray dose rates (low-range or high-range output) measured at the monitoring points are displayed with precipitation etc. (see Fig.7.3)

e) Meteorological trends display
By defining the output format previously (time axis, scale etc.), trend graphs of wind direction, wind speed and precipitation are displayed. (see Fig.7.4)

f) Generic trends display
Trend graphs of given data items are displayed for up to seven local telemeter units in a single picture. Linear or logarithmic scales are available. (see Fig.7.5)

g) Lists of the exposure dose estimated by the model
Ground level maximum radioactive concentrations in air, the γ-ray dose rates and external and internal exposure doses for each nuclide released are estimated and listed with the direction and the distance. (see Fig.7.6, Fig.7.7, Fig.7.8)

4. Equipment Specifications

Equipment specifications of the environmental radiation monitoring system are shown in Table 5.

* The wind direction and wind speed with the measuring height and atmospheric stability
* Operational state of reactors etc.

b) Meteorological data overview
The 1-min value data obtained at the meteorological tower are displayed on the map panel, being renewed every one minute. (see Fig.7.2)

c) Alarm values overview
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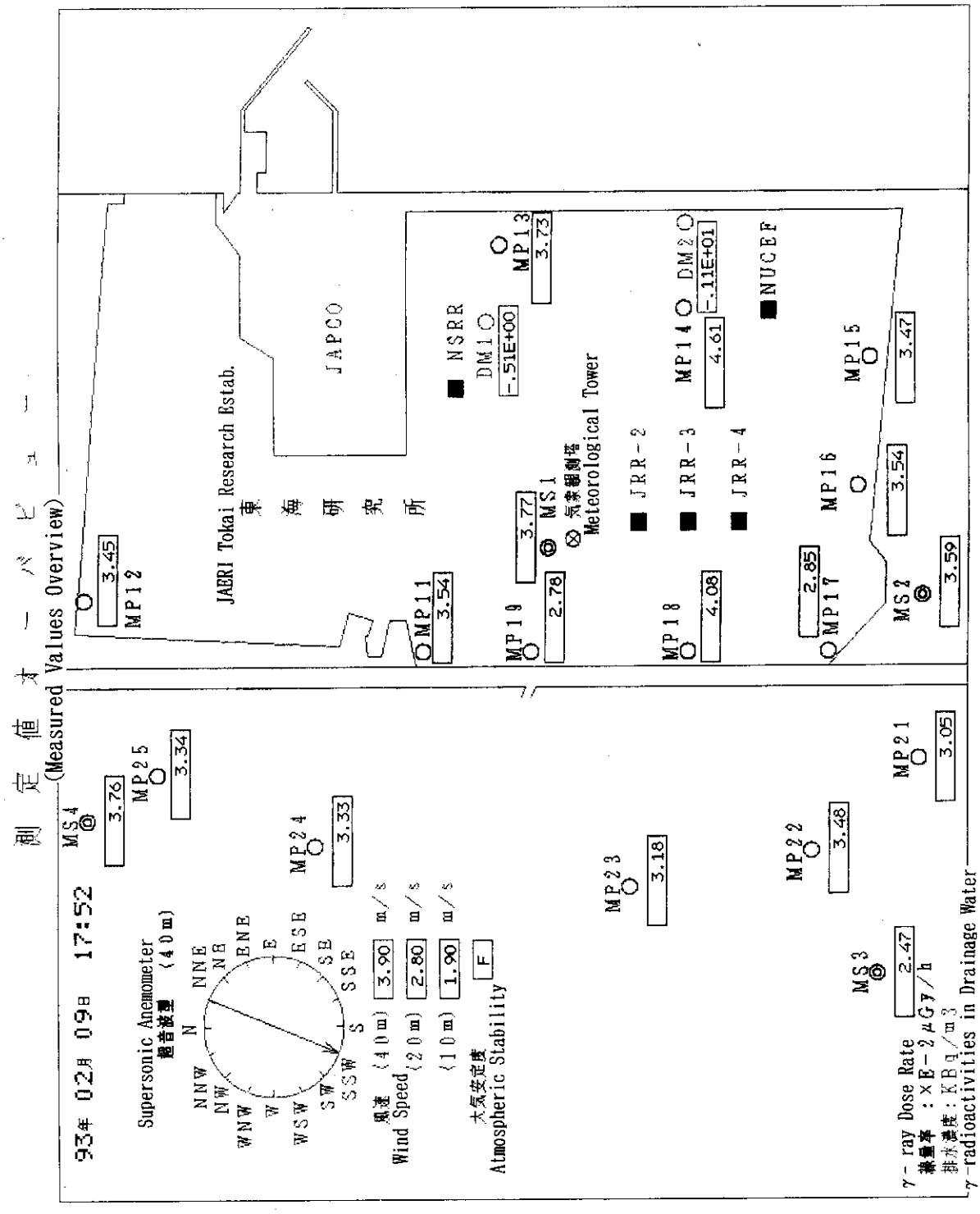

Fig.7.1 Measured Data Overview

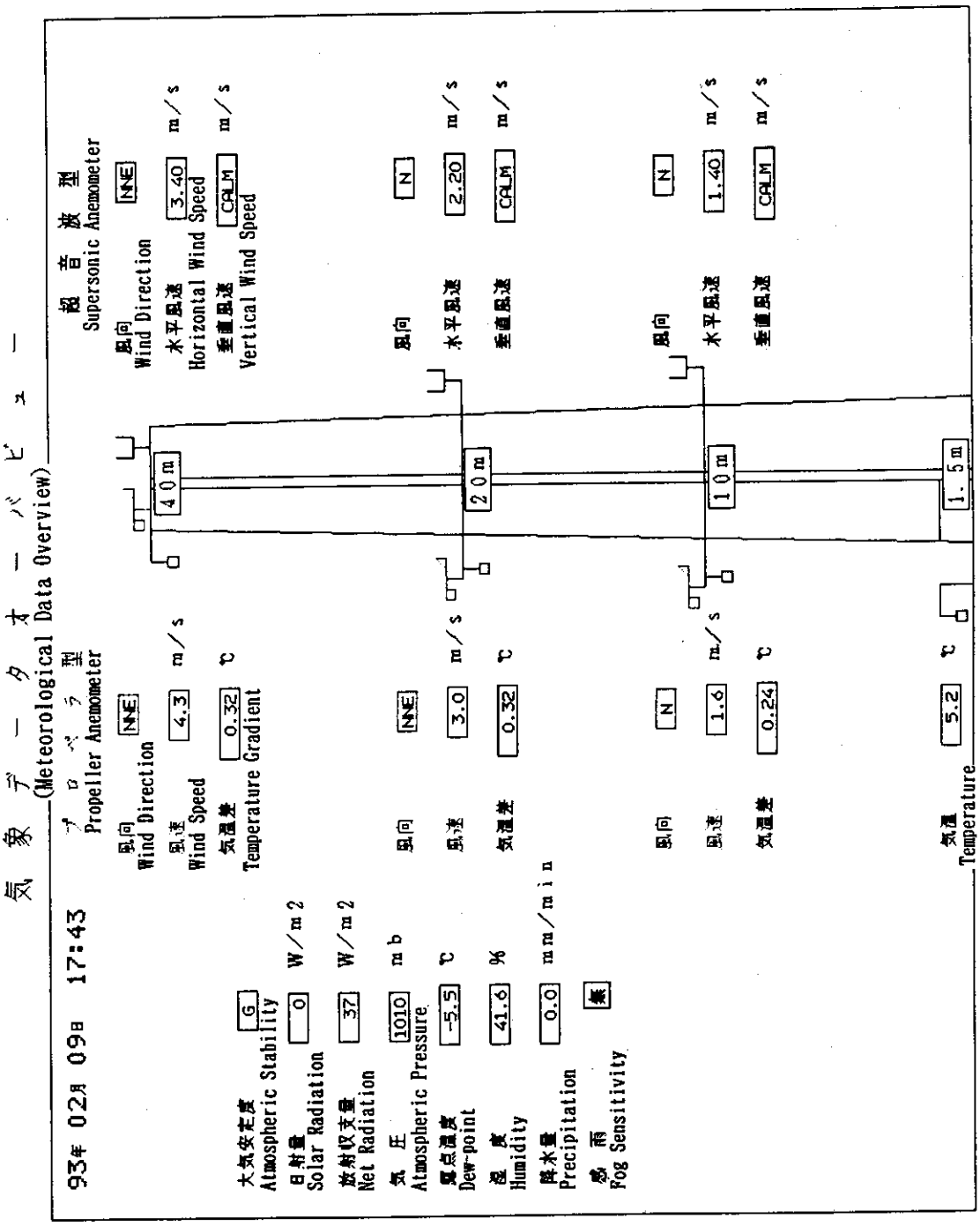

Fig.7.2 Meteorological Data Overview

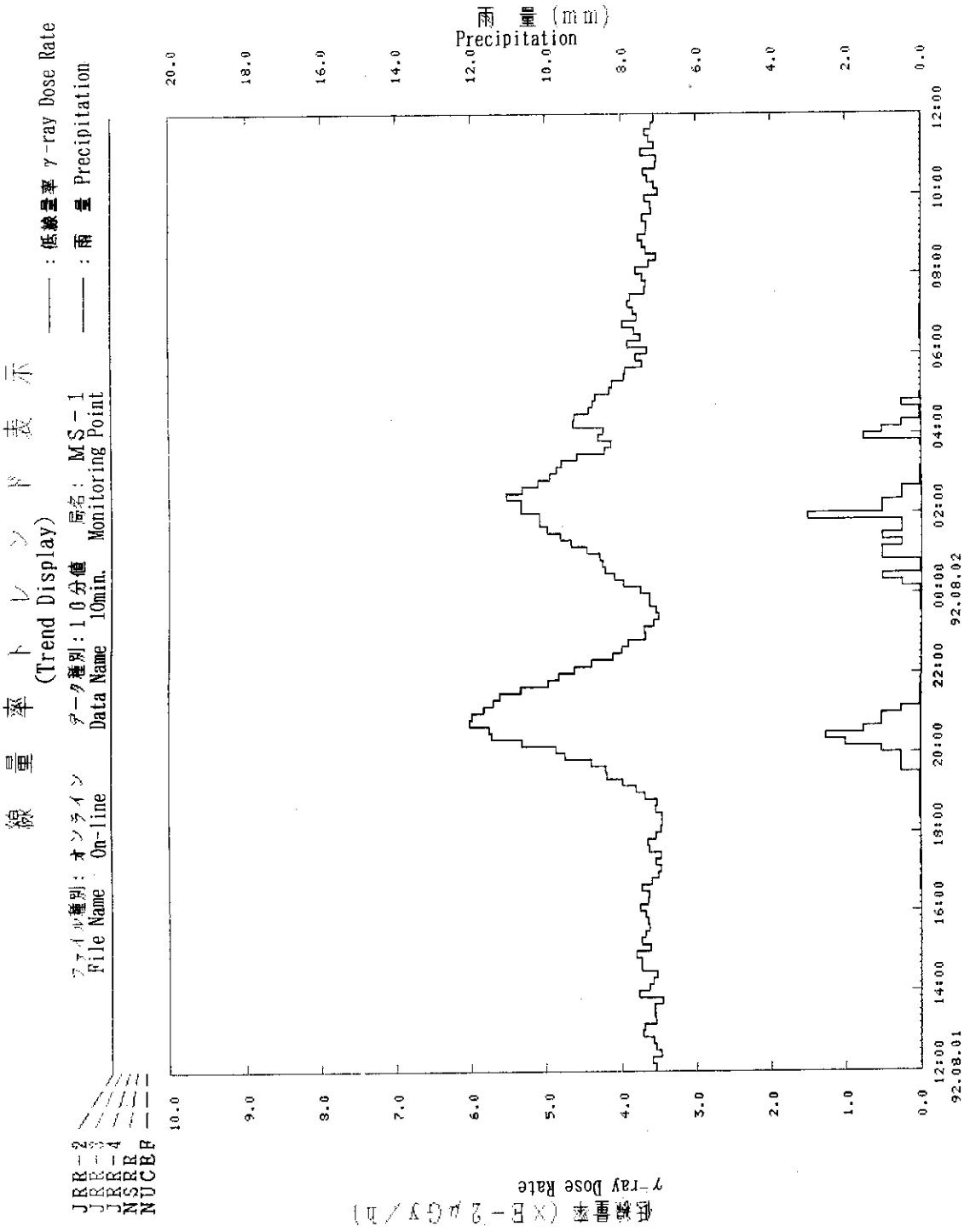

Fig.7.3 Trend Display of γ－ray Dose Rate and Precipitation

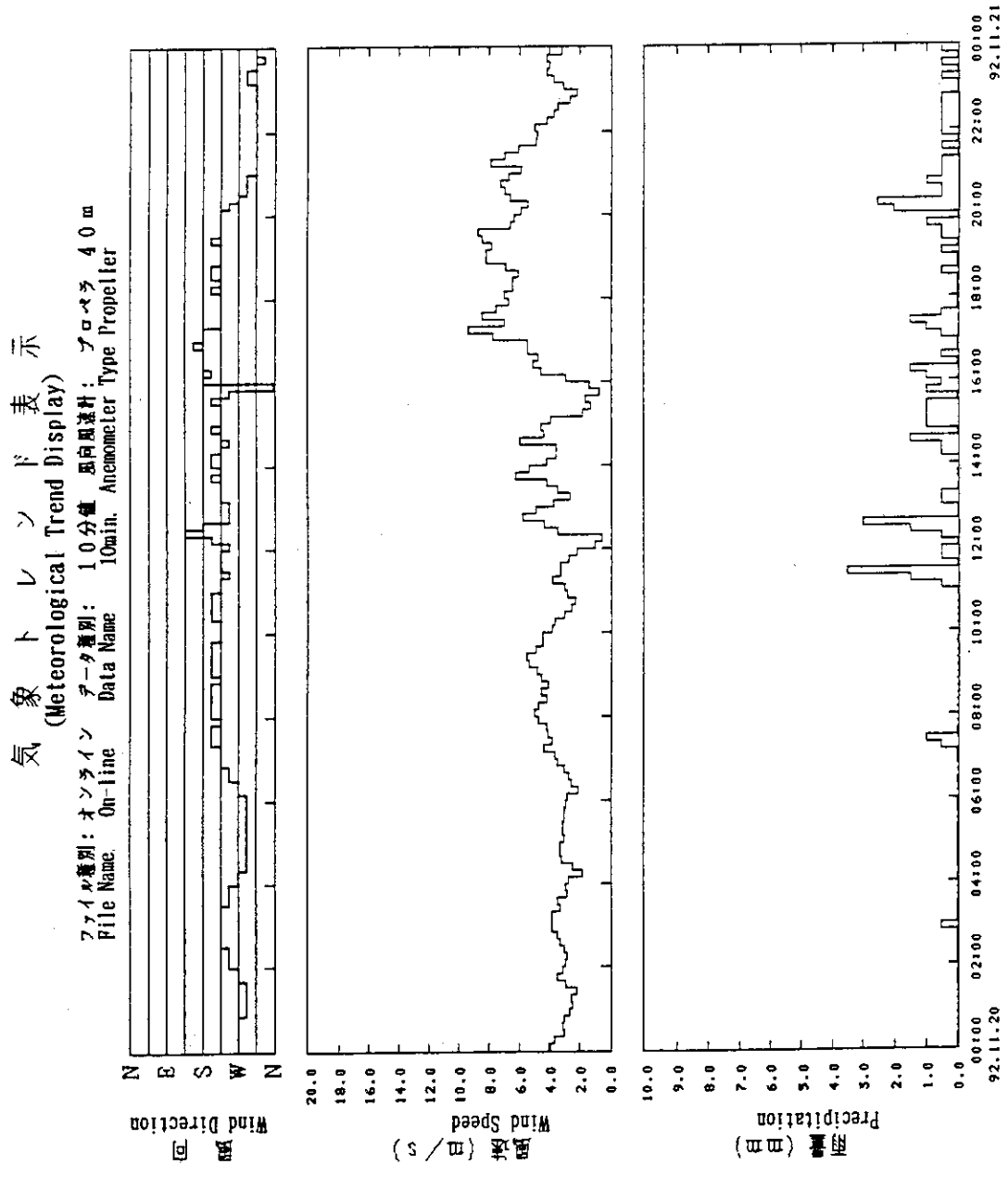

Fig.7.4 Trend Display of Meteorological Data

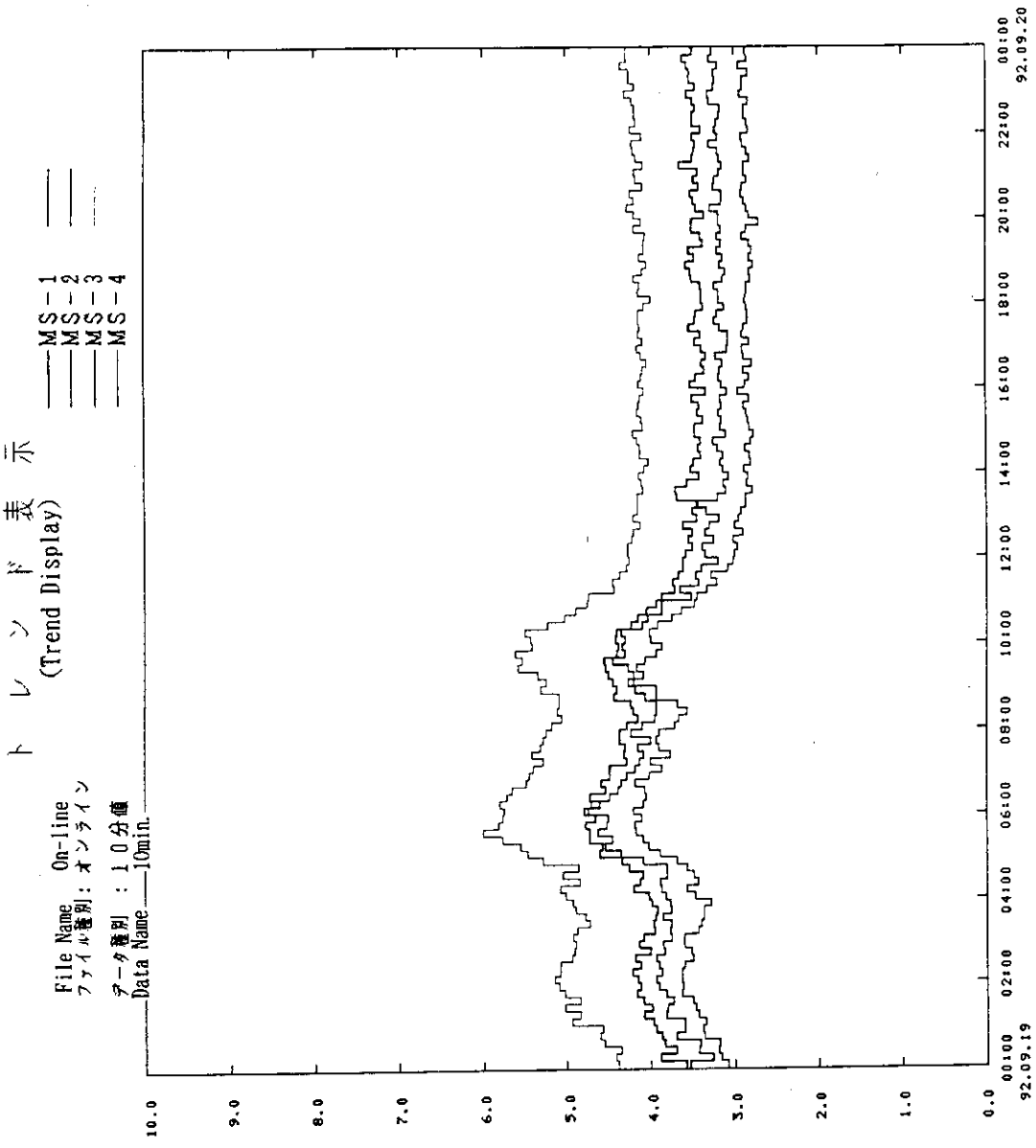

Fig.7.5 Trend Display of Generic Data

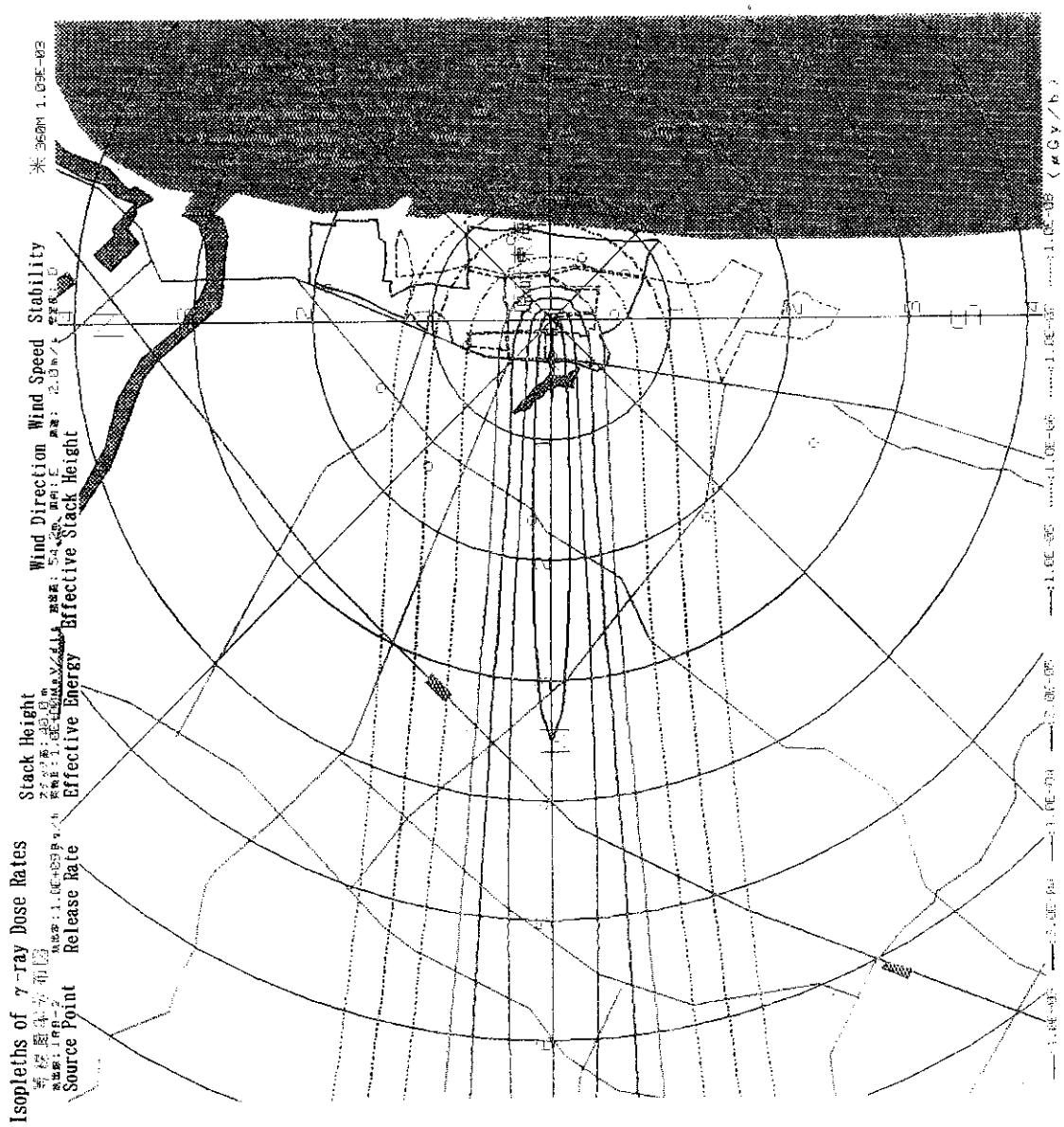

Fig.7.6 Isopleths of Surface Air Absorbed Dose Rate

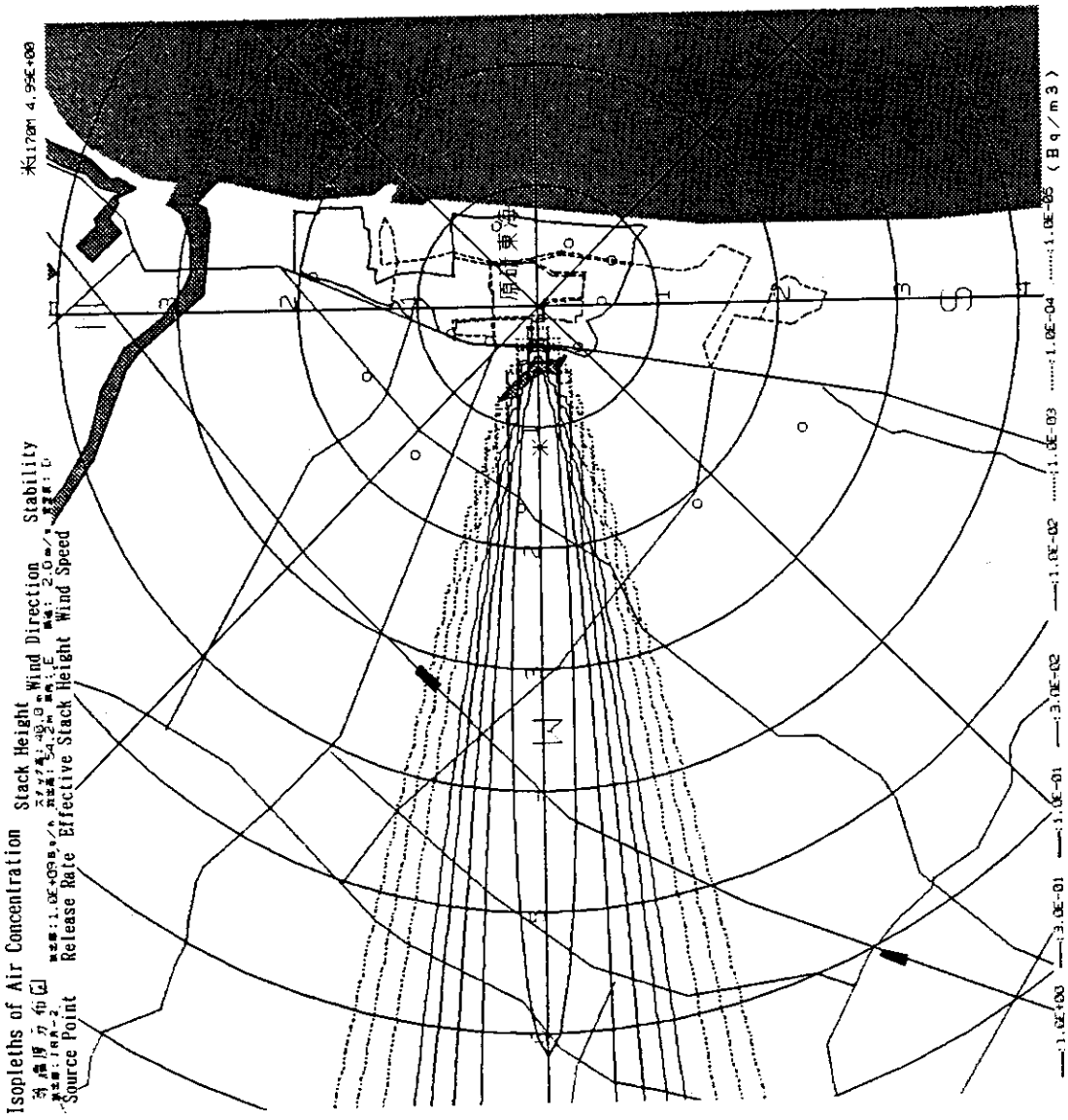

Fig.7.7 Isopleths of Surface Air Concentration

(Result of the Exposure Dose Calculation)
線量当量計算結果

Date 年月日時分	93.02.03 12:10
Wind Direction 風向	E
Wind Speed 風速（m／s）	2.60
Atmospheric Stability 大気安定度	B
Facility Name 施設名	JRR-2
Stack Height 放出高（m）	40.0
Exposure Time 被ばく時間（h）	1.0

Point of the Maximum Concentration
最大濃度地点
（3．7E10Bq／h）

Maximum Value 最大濃度（Bq／m3）	Distance 距離（Km）	Direction 方位
3.40E+02	0.38	W

Concentration on Boundary

監視区域上濃度	距離	方位
3.40E+02	0.37	W

Point of the Maximum γ-ray Dose Rate
最大空気吸収線量率地点
（3．7E10Mev・Bq／h）

Maximum Value 最大線量率（μGy／h）	Distance 距離（Km）	Direction 方位
1.71E-02	0.37	W

γ-ray Dose Rate on Boundary

監視区域上線量率	距離	方位
1.71E-02	0.37	W

Maximum Effective Dose Equivalent (Inhalation)
最大実効線量当量（内部被ばく）（mSv）

Nuclide 核種名	Release Rate 放出率（Bq／h）	Effective Dose Equivalent 実効線量当量	Gonads 生殖腺	Breast 胸部	R Marrow 骨髄	Lungs 肺
I-131 D	1.00E+09	9.70E-05	0.0	0.0	0.0	0.0
合計	1.00E+09	9.70E-05	0.0	0.0	0.0	0.0

Nuclide 核種名	Thyroid 甲状腺	Bone Surf 骨表面	Liver 肝臓	Soft T 軟組織	Skin 皮膚
I-131 D	3.20E-03	0.0	0.0	0.0	0.0
合計	3.20E-03	0.0	0.0	0.0	0.0

Maximum Effective Dose Equivalent (External Exposure)
最大実効線量当量（外部被ばく）
（mSv）

1.75E-07
1.75E-07

Fig.7.8 List of the Exposure Dose Estimated by the Model

Table 5 Equipment Specification of the Environmental Radiation Monitoring System

1. Local telemeter units (1/8)

Items			Specification
Data transmission	Telemeter type Data transmission speed Signal form Communication type		1 : N polling digital telemeter 1200 BPS NRZI (Non Return to Zero Invert) Half duplex type
Line strucuture	Line type Channel type		NTT 3.4 kHz specific communication line, two-line type Voice calling type, change-over with telemeter
Processing	Number of basic instructions Memory control capacity		33 (variation 345) 64 kW
Main memory	Element Capacity		IC memory Up to 64 kW for both ROM and RAM.
Clock	Clock oscillation Clock oscillation accuracy Time range Leap year compensation Outage compensation		Quartz oscillation type Error per day, ±0.1 sec Lower two digits of the year;two digits for the month, hour, minute and second, respectively Automatically up to the year 2099. Compensation items : clock oscillation, timing. Duration : up to 48 hours. Battery : Ni-Cd dry battery
Display setteing panel	Display	Display element	LED digital display
		Display number	16 digits (9 digits for data display)
Speaking	Type Microphone Communication type		Voice calling type Carbon type hand microphone Half duplex type (press-to-talk)

1.1 Voltage-withstand transformer

Items		Specification
Input	Voltage, frequency	AC 100V 50Hz
Capacity		5 kVA
Voltage-withstand	Between primary winding ～ seocndary winding Between secondary winding ～ shield	AC 10 kV, 1 min AC 3 kV, 1 min

2. Central telemeter unit (2/8)

Items			Specification
Data transmission	Telemeter type Data transmission speed Signal form Communication type		(1:N) ×3 polling digital telemeter 1200 BPS NRZI Half duplex type
Line structure	Line type Channel type		NTT 3.4 kHz, specific communication line, two line type 32 lines: (breakdown) ・Monitoring posts ; max. 15 lines ・Monitoring stations; max. 5 lines ・Drain monitors ; max. 3 lines ・Stack monitors ; max. 6 lines ・Meteorology ; max. 1 lines up to total 30 lines(use) Voice calling type, change-over with telemeter
Processing	Type Number of basic instructions Memory control capacity		16-bit microprocessor control type 33 (variation 345) 64 kW
Main memory	Element Capacity		IC memory Up to 64 kW for both ROM and RAM.
Host cpu Interfance	Communication type Transmission speed		PLC (Parallel Line Communication) About 70 kW/sec (1 W=16 bit)
Clock	Clock oscillation Clock oscillation accuracy Timing range Leap year compensation Outage compensation		Quartz oscillation type Error per day, ±1 sec. Lower two digits of the year ; two digits for the month, hour, minute and second, respectively Automatically up to the year 2099. Compensation items : clock oscillation, timing Duration : up to 48 hours. Battery : Ni-Cd dry battery
Magnetic bubble memory	Element Memory capacity Data transmission speed		Magnetic bubble memory (non-volatile memory) 1.5 Mbyte 12.5 kbyte/sec.
Communication control mechanism	Speaking control	Type Communication type Speaking control	Voice calling type Half duplex type (press-to-talk type) Master unit ←→ local units possible Master unit ←→ Master unit, impossible Local units ←→ local units, impossible
Power supply control	Input Power input system Overcurrent countermeasure Abnormality indication		AC 100V, 50 Hz Main system, one Auxiliary system,one In-common, communication control mechanism, one (system) (duplex) NFB On-panel lamps, contact output to the console.

3. Keyboard Printer (3/8)

Items			Specification
Printout	Printout characters	Structure	9 dots×5 dots
		Maximum number of digits per line	136 digits
		Incorporated characters	JIS 128 characters
	Printout mechanism	Printout speed	150 characters/sec
Interface	Type Transmission speed		RS-232-C (EIA) 9600 bit/sec

4. Console

Items			Specification
Display	Time display	Indicator	26 mm high 7 segment LED (red)
		Display digits	12 digits ; year, month, day time, minute second
	Lamp display	Indicator	LED indictor
		Display points	418
	Alarm inhibited	points connection	2 ; indication color, red. Telemeter master unit
	Collection on	points connection	2 ; indication color, amber. Telemeter master unit
	Control	points connection	2 ; indication color, amber. Telemeter master unit
	Monitor	points connection	2 ; indication color, amber. Telemeter master unit
	Alarm	points connection	64 ; indication color, red. Telemeter master unit
	3σ over	points connection	64 ; indication color, amber. Telemeter master unit
	Upper/lower limit over	points connection	64 ; indication color, red. Telemeter master unit
	Equipment abnormality	points connection	64 ; indication color, red. Telemeter master unit
	Adjustment	points connection	64 ; indication color, amber. Telemeter master unit
	No-response	points connection	64 ; indication color, amber. Telemeter master unit

(4/8)

Display	To-Mito transmission	points connection	1 ; indication color, amber. Telemeter master unit
	To-Oarai transmission	points connection	1 ; indication color, amber. Telemeter master unit
	With-local-unit speaking permitted	points connection	1 ; indication color, amber. Telemeter master unit
	Own master unit	points connection	2 ; indication color, red. Telemeter master unit
	Other master unit	points connection	2 ; indication color, red. Telemeter master unit
	Bubble memory abnormality	points connection	2 ; indication color, red. Telemeter master unit
	Host communication	points connection	2 ; indication color, red. Telemeter master unit
	Forced data lack	points connection	2 ; indication color, red. Telemeter master unit
Operation	External alarms test		MP alarm, MS alarm, Equipment abnormality
	Display panel off	Points	1
	To-Mito transmission	Points	3
	Confirmation	Points	1 ; flicker output continuously on, buzzer stop.
	Alarm rest	Points	1
	Buzzer off	Points	1
	Forced communication	Points	1 ; with-local-unit speaking forcedly permitted.
	Lamp test	Points	1
	Console power supply	Points	1
	Message off	Points	1

5. Uninterrupted power supply (5/8)

Items		Specification
Input	Voltage, frequency Number of phases Waveform distortion factor	100V ±12%, 50Hz Single-phase 10%
Capacity		3 kVA
Voltage		100V ± 2%
Voltage transient fluctuation	Input voltage ±10% rapid change Load 100% rapid change Outage, power resupply	± 5% ± 5% ± 5%

6. Wireless installation, Modem (for data transmission to Mito Atomic Energy Office)

Items			Specification
Wireless installation	Communication type		Data, simplex ; speaking, duplex.
	Radio frequency		70.32 MHz
	Transmission	Transmission output	10W
		Modulation type	Reactance phase modulation
		Frequency stability	± 1×10^{-7}
	Reception	Reception sensitivity	Up to 2 dB
		Spurious sensitivity	Up to -85 dB
		Low frequency output	2W or more
Modem	Modulation type Modulation frequency Transmission speed Standards applicable		FSK 1700Hz ± 400Hz 200BPS C.C.T.T.T.V.23 for the wireless installation C.C.T.T.T.V.24 for the data processing unit

7. Data processing unit (6/8)

Items			Specification
Unit			FACOM S-3300
Operation control	Data type register	Fixed, floating-point	8/16/32 bit
		Double word, quadruple word	64/128 bit
		General resistor	16 (32) bit
		Floating-points register	4 (64) bit
Main memory	Element		MOSLSI (64 kbit/chip)
	Memory capacity		8MB
	Interleaving		Two-way
	Battery support function		8MB for 10 min(retention of IC memory information)

8. Graphic display (outputs from 7. Data processing unit)

Items		Specification
Monitor	Unit	F9434B
	Monitor	20-in color
	Color display	7 colors + green
Character picture	Number of display characters	1920 characters (80 characters × 24 lines)
	Display function	Flicker, inverted table, no-display, underline

9. Display unit (console outputs from 7. Data processing unit)

Items		Specification
Monitor	Specification	F6262K 2
	Monitor	14-in
	Display colors	Green, white, red
Character picture	Number of display characters	Alphanumeric, kana : 1920 characters (80 characters × 24 lines)
Other		Light pen

10. Graphic unit

(7/8)

Items			Specification
Unit			FACOM U-1500Ⅱ
Operation control	Data type	Binary fixed point	8/16/32 bit
		Floating-point	3/64 bit
	Command	Instruction length	1/2/3 word
		Number of instructions	164
Main memory	Element		MOSLSI (64 kbit/chip)
	Capacity		2 Mbyte
	Battery-support function		2 Mbyte for 10 min (retention of IC memory information)

11. Graphic display (Display unit of the graphic unit)

Items		Specification
Monitor	Unit	D-SCAN GR-2603
	Monitor	26-in color
	Color display	6 colors + 1 color (background)
Controller,graphic	Segment, buffer	120 kbyte (max. 760 kbyte)

12. Magnetic disk units

Items		Specification
Magnetic disk	Units Memory capacities Average position time Average rotational delay time Data transmission speed	F6414R (one unit), F6415R (three units) 157 Mbyte × 1 unit, 256 Mbyte×3 units 20 ms 8.3 ms 2.46 Mbyte/S

13. Magnetic tape unit

Items		Specification
Unit		F 617 A1
Data transmission speed	Streaming mode	781/200 kB/s
	start-stop mode	470/120 KB/s
Recording density		6,250/1,600 BPI
Tape legth		2,400 ft

14. NIHONGO line printer (8/8)

Items		Specification
Unit		F 6718 C
Print type		Dry-type electrophotography by laser writing
Printout speed		1000 line/min (6 line/in) 2000 line/min (12 line/in)
Character generator	Basic	Alphanumeric/kana, 255 characters ; kanji, 8192
	Character capacity(additive)	18432 characters
Character structure	Alphanumeric, kana	24×30 dot
	Kanji	30×30 dot
Resolution		240 dots/in
Format print		Format overlay

15. Personal computer (the work station of the data processing unit)

Items		Specification
Unit		FACOM 9450 Λ
Microprocessor		MN1617 (16 bit microprocessor)
Memory	RAM	1 Mbyte
	VRAM	512 Kbyte
File	Memory capacity	5-in floppy disk (IBM), microdisk (20MB).
Display	Picture size	14-in
	Display colors	18 colors
	Number of display characters	Alphanumeric and kana, 1920 characters (80 characters× 24 lines) ; NIHONGO, 960 characters

5. Results of Observation

The research reactors in Tokai Research Establishment of JAERI are so designed and operated that the effective dose equivalent due to the gaseous and liquid radioactive wastes will be less than 50 μSv per year (1/20 of the legal 1 mSv/year) for the general public according to the " Guide on Objective Dose for General Public in the Vicinity of Light Water Nuclear Power Reactor Facilities"[4]. As it is generally difficult to measure the influence due to release from facilities separately from the fluctuation in natural radiation (the natural radiation largely varies with rainfall, geology, topography, etc.), above guide recommend to calculate the exposure doses from the released quantities on the basis of realistic models and parameters.

As one of the abnormal check options, the EMS has "mean value + 3σ" limit for the γ-ray dose rates, which exceed the "mean value + 3σ" at the time of rainfall in most case due to natural occurring radon daughters in rainwater.

In the following, some examples observed by the system will be described. The fluctuations of Fig.8 show the results of separation of the γ-ray dose rate due to ^{41}Ar from a research reactor and the natural γ-ray dose due to the radioactivities in rain. Figure 9 shows an example the γ-ray dose variations due to ^{41}Ar released from JRR-2 research reactor at the monitoring posts around the site of Tokai Research Establishment. It is seen that the γ-ray dose rates at the downwind monitoring posts have increased corresponding to changes in wind direction. Similarly observed data at the monitoring posts for one year from May 1977 to April 1978 were analyzed statistically by grouping the wind direction and rainfall to evaluate the exposure due to γ-ray from the reactor facilities and rain separately. It was found that a point on the boundary of the site (MP-7 in Fig.1), downwind of the prevailing wind direction, showed the maximum yearly dose of 1.1 mR[*1] (the dose due to rainfall in the corresponding period was 0.4 mR). It was shown that by analyzing the data of γ-ray dose rates obtained by the EMS using the meteorological data, the γ-ray dose can be evaluated at sufficiently very low levels.

Figure 10 shows the verification result of the methodologies and the models used in the EMS and shown in the "Guide on Meteorological Conditions for Safety Analysis of Nuclear Power Reactor Facilities" [5]. The verification study was done by using every 10 minute's meteorological and γ-ray dose rates data affected by ^{41}Ar released from the research reactors in JAERI measured at the monitoring posts. The monthly doses calculated

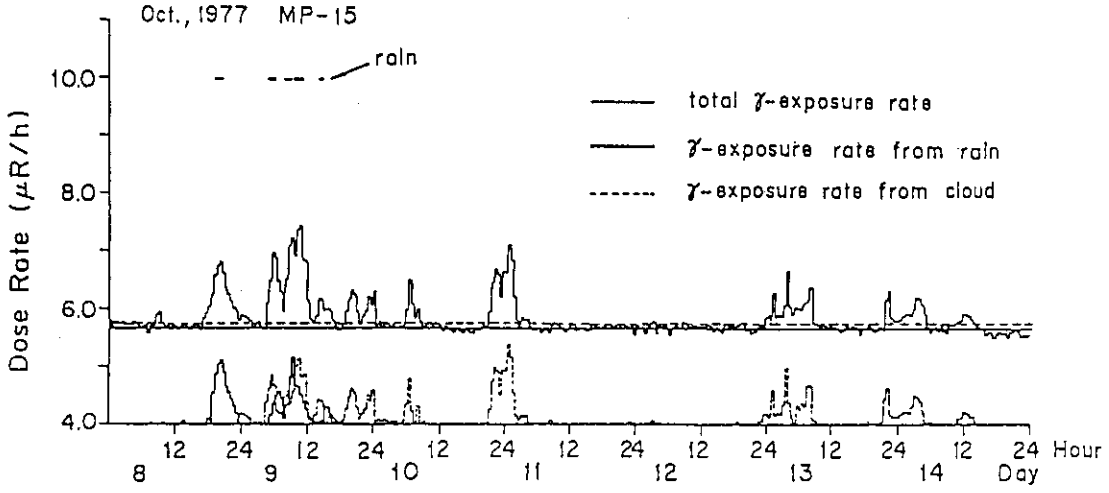

Fig.8 Result of the Separation of the γ Dose Rate due to ^{41}Ar and the Natural γ－ray Dose due to the Radioactivities in Rainwater

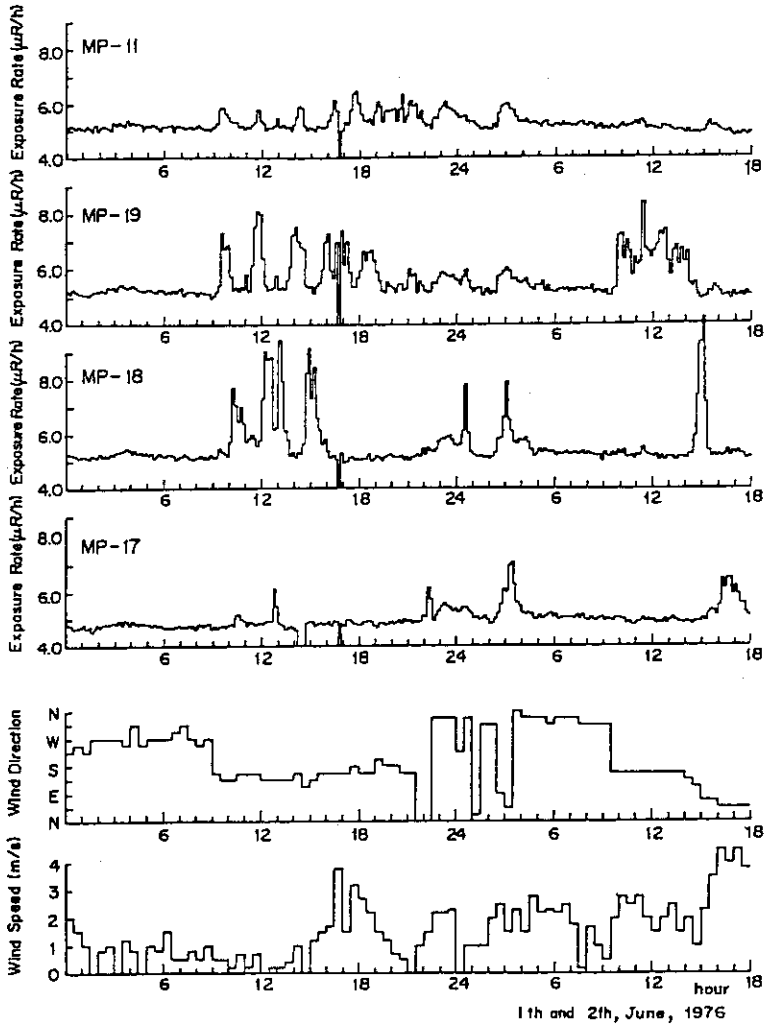

Fig.9 Variation of γ Exposure Rate Caused by the ^{41}Ar Released from JRR－2 (Released rate : 1.7×10^{10}Bq/h)

with the respective models are in relatively good correlation with the separated monthly doses obtained by above mentioned statistical method[6]. It is therefore shown that, around the site of Tokai Research Establishment where ground configuration is relatively flat, the methods by the two models are effectively applicable to routine environmental radiation control.

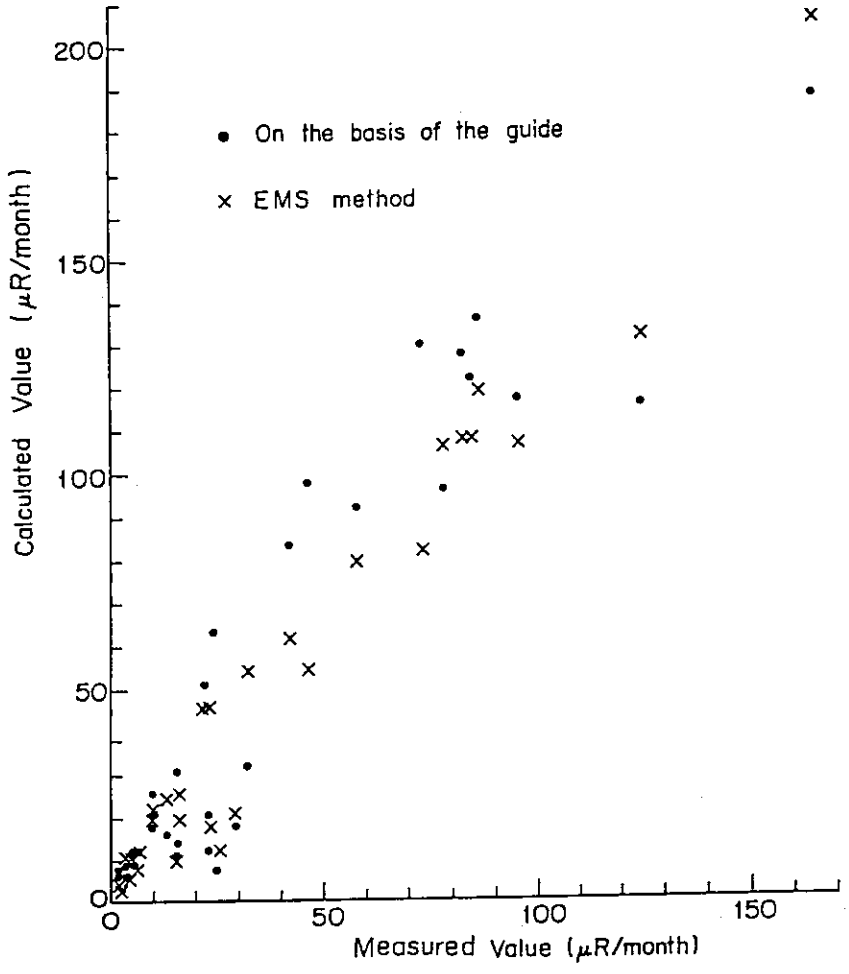

Fig.10 Verification Result of the Methodologies and the Model Used in the EMS

In 1960, as part of the environmental radiation monitoring around the site of the reactor facilities, an automatic monitoring of environmental radiation was started using a "relay" computer, since then, renewal of the system was made twice. EMS has been consolidated though these renewal by implementing up-to-date technologies in radiation measuring instruments and a computer and its peripheral equipment. Although the differences in the standpoint between the operators and local governments result in the

difference of monitoring items and points in the environmental monitoring program among them, basic ideas underlying the JAERI's system are extensively applied to their centralized environmental monitoring systems.

An outstanding feature of the system differing from other periodical environmental monitoring practices such as the measurement of γ－ray dose rate by a monitoring car, measurement of radioactivities in environmental samples is that the system is operated under the around－the－clock－system. The system is composed of numerous components such as the central monitoring facility, fixed measuring stations, data transmission system etc., so that the entire system becomes generally high cost comparing the periodical monitoring.

However, the monitoring system has played important roles in relation to the public acceptance of nuclear facilities, as it constantly monitors the environmental radiation and radioactivity in normal operation of such facilities and the results are directly shown to the public (mainly to the local government). Subsequently to the TMI－2 reactor accident, importance of the automatic centralized monitoring system has been recognized in the respect that it can collect rapidly reliable information on the environmental radiation. It is especially recommended by the Government that the operator of reactors, in particular, should install detectors being able to measure the γ－ray dose rate up to $\sim$0.1Sv/h (about 106 times that of the natural radiation). As the safety of reactor facilities in Japan is strictly reviewed by the Japan Nuclear Commission at the stage of design on all aspects of safety and followed by the approval of construction on the hard－ware of the reactor system and the quality assurance of the materials used and by the pre－operational inspection before routine operation and periodical inspection after commission by the national regulatory body, probability of the occurrence of any major accidents is believed to be very low or almost zero in the future. But in very rare cases of emergency, it should be possible to set up the countermeasures to protect the public on the basis of information provided by the automatic monitoring system and other emergency response system[*2].

[*1] Here regarded as 10 μSv $\fallingdotseq$ 1 mR

[*2] System for predicting extensively the doses with SPEEDI(System for Prediction of Environmental Emergency Information) with Meteorological Agency's meteorological data (AMEDAS) are provided by the Government.

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