RADIATION SAFETY CONTROL IN RIKEN RING CYCLOTRON FACILITY

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Introduction

A Radiation Safety Control System (RSCS) for RIKEN Ring Cyclotron (RRC) consists of a radiation monitoring system and a radiation protection control system. A large number of devices for the RSCS are distributed in RRC building. Since there are more than three hundred parameters and intricated control sequences for operating the RSCS, a computer control system is introduced; the host computer is a MITSUBISHI MX-3000.

Radiation monitoring system

Four monitoring posts at the boundary of the Accelerator Facility and one in the control room have been installed to measure the leakage-radiation during operation of RRC. A NaI(Tl) scintillation detector and a helium-3 counter are placed in each post to detect environmental γ-rays and neutrons, respectively, besides, sixteen ionization chambers and thirteen BF_3 counters are used to measure the radiation level at AVF cyclotron vault, RRC vault and the experimental rooms.

In order to measure the radioactivity in drain water and in the air of the experimental rooms and at the exit of the exhaust duct, four activity monitoring stations have been built in RRC building. The radioactivity in the drain water is measured with a NaI(Tl) and plastic scintillation detector.

The radioactivity in the air (gases and airborne dust) is measured with a NaI(Tl), ZnS(Ag), and plastic scintillation detector. All the data coming from monitors are logged periodically by the MX-3000 and stored in diskfiles; the MX-3000 can draw a graph by using those data. Table 1 shows the performance of the radiation monitors.

Leakage-radiation during operation of RRC has been measured inside and outside RRC building. Figure 1 shows an example of the intensity increase when a 135 MeV/u 7^+ nitrogen beam was accelerated and transported on the target at the E1 experimental room on October 1991. The beam intesity was 20-50 nA. No leakage γ-rays and neutrons from RRC building was detected.

Radiation protection control system

The radiation protection control system consists of card-operated gate-bars, safety keys, operation status lamps, radiation level indicators, shield doors, hand-foot-clothes monitors, and rotary shutters. Figure 2 shows a block diagram of the Radiation protection control system.

The entrance to and exit from the controlled area are checked very strictly by a personal card. At the entrance of each experimental room the radiation level inside the room is displayed on the radiation level indicators, by indicating each level with Green, Yellow, or Red. The operation conditions of RILAC, the AVF cyclotron, and RRC are also displayed on the operation status lamps.

RRC is controlled with a computer system,[1] consisting of a MITSUBISHI M-60, which is linked with the MX-3000 of the RSCS. For radiation safety, the MX-3000 has the highest priority in accelerator operation. Before starting operation, an operator should ask the MX-3000 for permission. If any erratic conditions occur in the RSCS during operation, The MX-3000 sends a beam-stop command.

The MX-3000 permits RRC operation, when

(a) No person is in AVF cyclotron vault, RRC vault and the experimental room where beams

Table 1. The performance of the radiation monitors

Monitors (number)	Detectors	Measured range	Sencitivity	Note
Outdoor Monitors	γ : NaI(Tl)	γ : 0~15μSv/h	γ : 1μSv/h =120cps	γ : 50keV~3MeV
(γ: 4 n: 4)	n : ^{3}He	n : 0~10^5μSv/h	n : 1μSv/h =1.5cps	n : 0.025eV~10MeV
Control Room Monitors	γ : NaI(Tl)	γ : 0~15μSv/h	γ : 1μSv/h =120cps	γ : 50keV~3MeV
(γ: 1 n: 1)	n : ^{3}He	n : 0~10^5μSv/h	n : 1μSv/h =1.5cps	n : 0.025eV~10MeV
Indoor Monitors	γ : Inonization chamber	γ : 0~10^4μSv/h	γ : 0.1μSv/h	γ : 27keV~2MeV
(γ: 16 n: 13)	n : BF_3	n : 0~10^5μSv/h	n : 1μSv/h =0.4cps	n : 0.025eV~10MeV
Air (Gas) Monitors (γ: 2)	γ : NaI(Tl)	γ : 0~10^5cps	γ : ^{41}Ar:5.6×10^{-3} Bq/cm^3	
Exhaust Gas Monitor (γ: 1)	γ : NaI(Tl)	γ : 0~10^5cps	γ : ^{41}Ar:5.6×10^{-3} Bq/cm^3	
Exhaust Dust Monitors	α : ZnS(Ag)	α : 0~10^5cps	α : 7.4 × 10^{-10} Bq/cm^3	
(α: 1 β: 1)	β : Plastic	β : 0~10^5cps	β : 4.4 × 10^{-9} Bq/cm^3	
Drain Water Monitors	β : Plastic	β : 0~10^5cps	β : ^{40}K: 1.7 × 10^{-2} Bq/cm^3	
(α: 1 β: 1)	γ : NaI(Tl)	γ : 0~10^5cps	γ : ^{40}K: 1.3 × 10^{-2} Bq/cm^3	
Hand-Foot-Clothes Monitors	α : ZnS(Ag)	α : 0~10^6count	α : 2.6 × 10^{-2} Bq/cm^2	
(α: 1 β: 2)	β : Plastic	β : 0~10^6count	β : 2.2 × 10^{-1} Bq/cm^2	

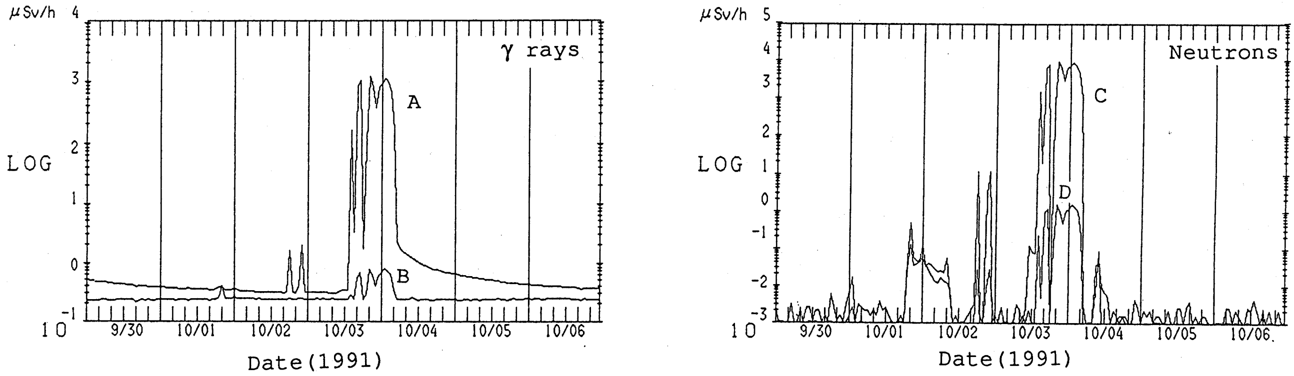

Fig.1. Comparison of day variations of the radiation level measured with radiation monitors in the E1, and E2 experimental rooms. A: γ-rays in E1 room, B: γ-rays in E2 room, C: neutrons in E1 room, D: neutrons in E2 room.

will be used;

(b) The shield doors are closed in AVF cyclotron vault, RRC vault and the experimental room where beams will be used;

(c) The rotary shutters are open in the beam course where the beam will be used; But other rotary shutters are closed.

Persons are not permitted to enter the relevant vault or rooms, when

(d) AVF cyclotron is in operation;

(e) RRC is in operation;

(f) Beams are being handled in the experimental room;

(g) The radiation level of the experimental room is Red level, or the radioactivity in the air of the room is at high level.

Display on CRT terminal

The radiation level of each experimental room is also indicated with color, Green, Yellow, or Red, which is displayed on four Cathode Ray Tube (CRT) terminals together with the number of persons working in this area. The radioactivity in the drain water and in the air also displayed on these CRT terminals. The status of safety keys, AVF cyclotron operation, RRC operation, shield doors, rotary shutters, and ventilating damper are also displayed on these CRT terminals, which are placed on the RSCS control desk, RRC operation desk, and the underground passage. Figure 3 shows an example of display on CRT terminal; A nitrogen beam from RRC (Injector: AVF cyclotron) was transported on the target at the E1 experimental room on October 1991.

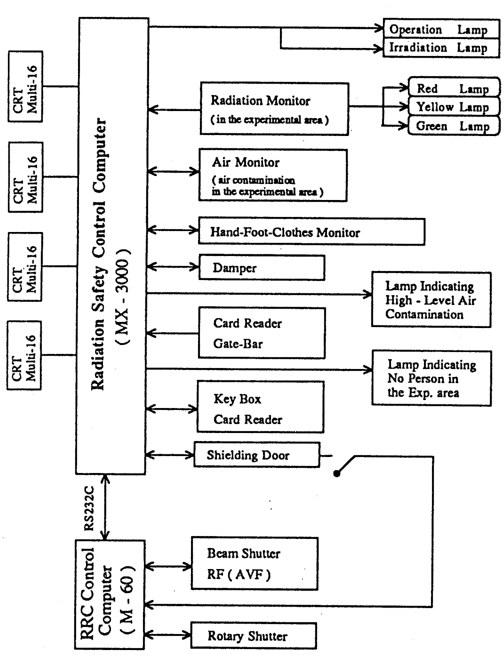

Fig.2. Block diagram of the Radiation protection control system

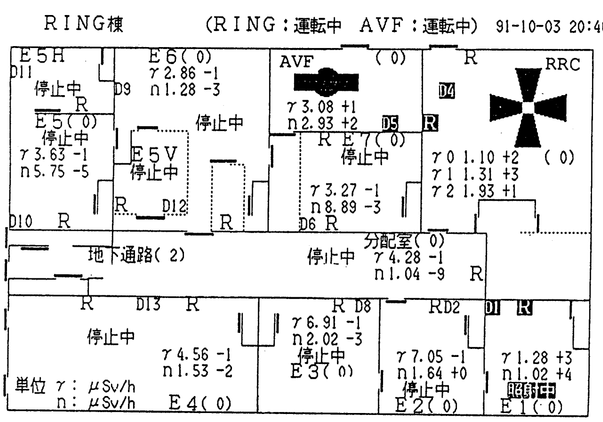

Fig.3. Example of display on CRT terminal.
R: Rotary shutter, D: Damper,
( ): Number of persons.
'γ 1.28 +3' means γ rays of 1.28×10^{3} μSv/h and 'n 1.02 +4' neutrons of 1.02×10^{4} μSv/h.

Personal monitoring

The external exposure doses were measured by using γ ray and neutron film badges. The doses received by accelerator workers from January to December 1990 are shown in Table 2. The external doses were detected for 11 persons: four RILAC operators, four nuclear chemists, and three other researchers. The collective dose owing to thermal and fast neutron exposures was below the detection limit.

Reference

1) T.Wada, H.Takebe, J.Fujita, T.Kambara, and H.Kamitsubo: RIKEN Accel.Prog.Rep.,20,170 (1986).

Table 2. Annual external exposure doses received by RIKEN accelerator workers from January to December 1990.

Workers	Number of persons				Collective dose (mSv)
	Dose Undetectable	0.1 -1 (mSv)	>1 (mSv)	Total	
Accelerator physicists and Operators *	40	4	0	44	0.9
Nuclear physists	163	0	0	163	0
Researchers in other fields	196	7	0	203	1.6
TANDETRON workers	17	0	0	17	0
Health physicist	7	0	0	7	0
Total	423	11	0	434	2.5

* Operators : For Ring cyclotron , Cyclotron , and RILAC .

Average annual dose per person , 0.006 mSv : Maximum individual annual dose was 0.6 mSv .