

VI. RADIATION PROTECTION AND MONITORING

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1. Individual Monitoring

Internal and external radiation doses were monitored for radiation protection, according to the radiation safety regulations. In this FY 2010, total 405 workers (184 workers registered in this institute and 221 visiting workers of other institutions) were monitored individually. External exposure doses have been monitored every month with glass badges sensitive to beta-, gamma -rays, thermal and fast neutrons for staffs, students and researchers. Digital pocket dosimeters have been in use as supplement. The glass badges were used for monitoring one centimeter dose equivalent and a tissue dose equivalent at $70 \mu\text{m}$ deep. The trend of annual collective doses were summarized in Table 1. Internal exposure doses were estimated using the concentration of work places, so that no internal doses were detected. The annual collective dose (for total of 184 workers) and the average effective dose per person were $13.3 \text{ man}\cdot\text{mSv}$ and 0.07 mSv/y , respectively. The maximum individual dose was 1.5 mSv/y in a worker of the accelerator. No worker was exposed to radiation beyond 20 mSv/y , or a dose limit regulated by the law. According to the law and orders by the regulation authorities, necessary reports were prepared and submitted.

2. Indoor Radiation Control

The Section of Indoor Radiation Control monitored the external radiation dose, the airborne radioactivity in air and the surface contamination in the controlled areas, regularly. The monitoring for the external radiation dose rate in the controlled areas were carried out with both fixed-position monitors and survey meters which can measure beta-, gamma-rays and neutrons during the period of the reactor operation. Ionization chambers, NaI scintillation counters and BF_3 counters are mainly used as the detectors for the fixed-position monitoring systems. The alert level for the radiation dose rate has been generally set at $20 \mu\text{Sv/h}$ in the controlled area. The external radiation dose accumulated for a week/month was also measured with glass badges at more than 30 locations in the KUR, KUCA containment buildings and other radiation facilities such as Linac and radioactive waste management.

Fixed-position monitors for radioactive gases and/or dust are installed both in work areas and exhaust lines. The dominant radionuclide resulting from the reactor operation is ^{41}Ar . In the early March 2010, new fuel were transported and set into the KUR. The monitoring related to the transport and re-setting was also carried out by this Section. The concentration of radionuclides

released from facilities was monitored continuously. There was no significant release, that is beyond the regulation levels.

3. Environmental Radiation Control

The Section of Environmental Radiation Control worked for assessing the internal radiation dose in the vicinity of the nuclear facility and radioactivities in environmental samples. In FY 2010, the KUR re-started, so we carefully monitor the radiation doses to the public. The effective dose on the public resulting from exposure by the effluent gas from reactor was estimated to be enough below the regulation levels.

The environmental monitoring and meteorological observation was continuously performed to obtain safety assurance data for the other facilities such as KUCA. Dose rates of the external radiation in the field were continuously measured by using NaI scintillation detectors set at five locations inside the KURRI area and four locations outside. The thermo-luminescence dosimeters (TLDs) are set up for measuring the radiation dose accumulated during the period of three months at locations outside the KURRI. No significant increase of the radiation level was recognized in relation to the reactor operation at any monitoring location. Temporary increases in the dose rate were attributed to events with the rainfall that entrains radon daughters. The external radiation doses for every three months at nine locations around the site are shown in Table 2.

Environmental samples including surface water, river and pond sediments, field soils, dusts and plants were collected in the vicinity of the KURRI twice a year during spring and autumn. Typical data on the environmental radioactivity are given in Table 3. The total activities in beta- and gamma-nuclides, which were measured with a low background counter using a windowless gas flow and/or a Ge(Li) detector, showed the ordinary natural radioactivity levels in any samples mentioned above. The content of ^{40}K in plants has a wide variation ranging from 5.1×10^1 to $7.3 \times 10^2 \text{ Bq/kg-wet weight}$ and thus, in some farm products it sometimes exceeded the maximum level reported in the past.

Liquid waste from the radioactive waste management facility or KURRI is discharged into a retention pond (named Imaiike) after treatment process. Neither the content of radionuclides beyond the regulation level was observed in the effluent water, nor radioactivity in any environmental samples exhibited tendency to increase with time.

Table 1 Number of radiation workers, collective dose, and average effective dose, per year, in FY 2006-2010.

	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010
Collective dose (man•mSv)	14.3	12.3	12.0	12.7	13.3
Number of registered radiation workers	198	186	188	191	184
Average effective dose (mSv)	0.07	0.07	0.06	0.07	0.07

Table 2 External doses accumulated quarterly by using thermo-luminescence detectors at nine locations around the KURRI site

Location	Period(quarter)	(μSv/quarter)				Total (μSv/year)
		First	Second	Third	Fourth	
KUR meteor. observ. tower		78	72	75	76	301
KUR south of ground		102	99	108	100	409
Bozu-Ike pond		58	60	57	58	233
KUR transformer station		74	78	70	81	303
KUR gate		66	69	68	66	269
Kumatori Wada st.		94	92	94	98	378
Izumisano Shimogawaraya st.		102	103	99	100	404
Izumisano municipal office st.		102	102	101	105	410
Izumisano Hieno st.		80	82	79	79	320

Table 3 Radioactivity concentration in environmental samples selected

Samples	Sanpling locations	Sampling date (D/M/Y)	Man-made nuclides			Natural nuclides			
			⁶⁰ Co	⁶⁵ Zn	¹³⁷ Cs	⁷ Be	⁴⁰ K	²⁰⁸ Tl	²¹⁴ Bi
Sediment (Bq/kg-dry)	Eiraku-dam	06/10/10	D.L.	D.L.	D.L.	12	640	9	16
	Oo-ike	05/10/10	D.L.	D.L.	D.L.	D.L.	575	9	18
	Inakura-ike	05/10/10	D.L.	D.L.	1	D.L.	519	D.L.	17
	Ameyama-gawa (Gomon)	06/10/10	D.L.	D.L.	D.L.	18	577	7	11
Soils (Bq/kg-dry)	KUR Hot Lab.	06/10/10	D.L.	D.L.	D.L.	D.L.	730	D.L.	25
	Kumatori-Wada	05/10/10	D.L.	D.L.	4	D.L.	537	10	20
	Hine shrine	05/10/10	D.L.	D.L.	D.L.	D.L.	557	14	23
	Aritoshi shrine	05/10/10	D.L.	D.L.	2	D.L.	456	24	39
Vegetables (Bq/kg-dry)	Eggplant (stalk, leaf)	27/10/10	D.L.	D.L.	D.L.	13.1	94.2	D.L.	0.2
	Persimmon	02/11/10	D.L.	D.L.	D.L.	D.L.	64.4	D.L.	D.L.
	Green pepper(stalk, leaf)	11/11/10	D.L.	D.L.	D.L.	15.7	217.1	D.L.	D.L.
	Lawn	06/12/10	D.L.	D.L.	D.L.	70.6	51.0	0.4	1.8
Rain water (Bq/l)	Meteor. observ. tower at KURRI	Sep.10 – Feb. 11	D.L.	D.L.	D.L.	D.L.	D.L.	D.L.	D.L.

* : D.L. denotes the measured values were below a detection limit.