

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 2011, total 550 workers (193 workers registered in this institute and 357 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 μ m deep. The trend of annual collective doses was summarized in Table 1. Internal exposure doses were estimated using the airborne radioactivity in air at work places, so that no internal doses were detected. The annual collective dose (for total of 193 workers) and the average effective dose per person were 12.5 man \cdot mSv and 0.06 mSv/y, respectively. The maximum individual dose was 1.2 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 was 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 BF₃ 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 μ 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 ⁴¹Ar. 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 radiation dose in the vicinity of the nuclear facility and monitoring the radioactivity 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 ⁴⁰K in plants has a wide variation ranging from 4.0 x 10¹ to 7.0 x 10² Bq/kg-wet weight. Small amount of ¹³⁴Cs was detected in some environmental samples due to the accident of TEPCO's Fukushima Daiichi Nuclear Power Stations.

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 2007-2011.

	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011
Collective dose (man•mSv)	12.3	12.0	12.7	13.3	12.5
Number of registered radiation workers	186	188	191	184	193
Average effective dose (mSv)	0.07	0.06	0.07	0.07	0.06

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

Location	Period(quarter)	First	Second	Third	Fourth	Total
		(μSv/quarter)				(μSv/year)
KUR meteor. observ. tower		73	73	74	70	290
KUR south of ground		99	94	100	92	385
Bozu-Ike pond		55	54	57	55	221
KUR transformer station		75	73	75	74	297
KUR gate		72	67	69	65	273
Kumatori Wada st.		93	89	85	89	356
Izumisano Shimogawaraya st.		96	96	94	102	388
Izumisano municipal office st.		94	98	90	102	384
Izumisano Hieno st.		78	76	73	74	301

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	12/10/11	D.L.	D.L.	1	11	655	10	14
	Oo-ike	04/10/11	D.L.	D.L.	D.L.	D.L.	534	10	17
	Inakura-ike	04/10/11	D.L.	D.L.	1	D.L.	535	10	15
	Ameyama-gawa (Gomon)	05/10/11	D.L.	D.L.	1	10	679	7	14
Soils (Bq/kg-dry)	KUR Hot Lab.	05/10/11	D.L.	D.L.	1	D.L.	701	13	18
	Kumatori-Wada	04/10/11	D.L.	D.L.	4	D.L.	613	12	18
	Hine shrine	04/10/11	D.L.	D.L.	1	D.L.	594	11	15
	Aritoshi shrine	04/10/11	D.L.	D.L.	6	D.L.	393	8	12
Vegetables (Bq/kg-dry)	Radish(leaf)	30/11/11	D.L.	D.L.	D.L.	D.L.	58.2	D.L.	D.L.
	Radish(root)	30/11/11	D.L.	D.L.	D.L.	1.3	40.4	D.L.	D.L.
	Butterbur	30/11/11	D.L.	D.L.	D.L.	6.1	84.5	D.L.	D.L.
	Lawn	07/02/12	D.L.	D.L.	0.2	42.2	159.2	0.4	D.L.
Rain water (Bq/l)	Meteor. observ. tower at KURRI	Sep.11– Feb. 12	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.