# VI. RADIATION PROTECTION AND MONITORING

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## 1. Individual Monitoring

According to the radiation safety regulations, total 392 workers (191 workers registered in this institute and 201 visiting workers of other institutions) were monitored individually for external and internal radiation exposures, in FY 2009. 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 $\mu$m deep. The trend of annual collective doses were summarized in Table 1. The annual collective dose (for total of 191 workers) and the average effective dose per person were 12.7 man・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 $\mu$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, but no radionuclides were discharged from the KUR stack due to the reactor being ceased since February 2006 for replacement of nuclear fuels. During this period, the maintenance and calibration have been continued for many equipments and facilities in FY 2009, including the monitoring posts, hand-foot-cloth monitors, dust samplers, and so on.

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.

## 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. Since the reactor (KUR) did not operated in FY 2009 for the replacement of its fuel, the effective dose on the public resulting from exposure by the effluent gas from reactor was estimated as nil due to no discharge of $^{41}$Ar.

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 $5.3 \times 10^1$ to $4.1 \times 10^2$ 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 Imaike) 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 2003-2007.

| | FY 2005 | FY 2006 | FY 2007 | FY 2008 | FY 2009 |
|---|---|---|---|---|---|
| Collective dose (man･mSv) | 21.2 | 14.3 | 12.3 | 12.0 | 12.7 |
| Number of registered radiation workers | 206 | 198 | 186 | 188 | 191 |
| Average effective dose (mSv) | 0.10 | 0.07 | 0.07 | 0.06 | 0.07 |

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

| Period(quarter) | First | Second | Third | Fourth | Total |
|---|---|---|---|---|---|
| Location | (μSv/quarter) | | | | (μSv/year) |
| KUR meteor. observ. tower | 82 | 90 | 80 | 88 | 340 |
| KUR south of ground | 87 | 88 | 99 | 90 | 364 |
| Bozu-Ike pond | 63 | 91 | 63 | 67 | 284 |
| KUR transformer station | 90 | 95 | 81 | 93 | 359 |
| KUR gate | 80 | 85 | 75 | 84 | 324 |
| Kumatori Wada st. | 93 | 94 | 97 | 100 | 384 |
| Izumisano Shimogawaraya st. | 103 | 106 | 106 | 112 | 427 |
| Izumisano municipal office st. | 104 | 105 | 105 | 110 | 424 |
| Izumisano Hieno st. | 84 | 88 | 86 | 89 | 347 |

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 | 22/10/09 | D.L.* | D.L. | 1 | D.L. | 670 | 10 | 15 |
| | Oo-ike | 21/10/09 | D.L. | D.L. | D.L. | 17 | 582 | 9 | 20 |
| | Inakura-ike | 21/10/09 | D.L. | D.L. | 1 | D.L. | 577 | 11 | 19 |
| | Ameyama-gawa (Gomon) | 22/10/09 | D.L. | D.L. | D.L. | 11 | 718 | 7 | 12 |
| Soils (Bq/kg-dry) | KUR Hot Lab. | 22/10/09 | D.L. | D.L. | D.L. | D.L. | 689 | 17 | 21 |
| | Kumatori-Wada | 21/10/09 | D.L. | D.L. | 5 | D.L. | 611 | 11 | 22 |
| | Hine shrine | 21/10/09 | D.L. | D.L. | D.L. | D.L. | 605 | 13 | 21 |
| | Aritoshi shrine | 21/10/09 | D.L. | D.L. | 7 | D.L. | 629 | 18 | 29 |
| Vegetables (Bq/kg-dry) | Radish (roots) | 08/12/09 | D.L. | D.L. | D.L. | D.L. | 60.8 | D.L. | D.L. |
| | Radish (leaves) | 08/12/09 | D.L. | D.L. | D.L. | 4.5 | 96.0 | D.L. | 0.3 |
| | Sweet potato (root) | 09/12/09 | D.L. | D.L. | 0.1 | D.L. | 315.5 | D.L. | 0.3 |
| | Lawn | 19/10/09 | D.L. | D.L. | 0.1 | 129.6 | 215.7 | D.L. | 0.5 |
| Rain water (Bq/l) | Meteor. observ. tower at KURRI | Sep.09 – Feb. 10 | 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.