§9. Evaluating On-Site Monitoring Cart Conceptually Developed for Radiation Workplace

Kawano, T.

To develop an on-site radiation monitoring cart (monitoring cart), necessary apparatuses including a NaI(Tl) scintillation survey meter, ^{3}He proportional neutron survey meter, alpha/beta measuring system, germanium spectrometer, HC collector, liquid scintillation counting system, dust sampler, and tritium gas monitor were selected from commercially available equipment. They were conceptually installed to construct a monitoring cart 1635 × 800 × 1500 mm. The cart was evaluated for its radiation detection limit.

For monitoring radiation dose, a NaI (Tl) scintillation survey meter and neutron survey meter can be used. As shown in Table 1, the detection limit of a NaI (Tl) scintillation survey meter is 0.1 μSv/h for gamma ray radiation and that of the neutron survey meter is 0.01 μSv/h for neutron radiation. The ratios of the detection limits to the legal limits are 4.00E-03 for gamma ray radiation and 4.00E-04 for neutron radiation. These results suggest that the radiation detection limits of these survey meters on the monitoring cart are sufficiently lower than those stipulated by the law.

Table 1 Comparison of detection and regulation limits of the radiation dose by using the cart.

Radiation	Device installed	Detection limit (Sv/h)	Detection limit/ legal limit
Gamma ray	NaI (Tl) scintillation survey meter	0.1	4.00E-03
Neutron	Neutron survey meters	0.01	4.00E-04

For monitoring radioisotope surface contamination, two methods are usually employed. These are direct measurement with survey meters (survey method) and sampling measurement by wiping with a smear paper (smear method). The survey method of the two is mainly used for checking qualitatively if contamination has occurred or has been removed. The radioactivity wiped on the smear paper is measured using the liquid scintillation counting system (^{3}H and ^{14}C), the alpha/beta radiation measurement system (alpha- and beta-emitting nuclides without ^{3}H and ^{14}C), or the germanium spectrometer (gamma-ray-emitting nuclides).

To estimate the performance, the alpha/beta measuring system was assumed to be regularly used. The detection limits are 0.05 Bq/cm^{2} for alpha-particle-emitting nuclides and 0.04 Bq/cm^{2} for other nuclides, as shown in Table 2.

Table 2 Comparison of detection and regulation limits of surface contamination by using the cart.

Radiation	Device installed	Detection limit (Bq/cm^{2})	Detection limit/ legal limit
Alpha	Alpha/beta measuring system	0.05	0.013
Other		0.04	0.001

Comparing these detection limits to the legal limits, the ratios are 0.013 and 0.001 for alpha-particle-emitting nuclides and other nuclides, respectively. For monitoring radioisotope concentration in the air, the tritium gas monitor is used to directly and continuously measure the tritium concentration in the air. In Table 3, the detection limit of the monitor is 1.1E-2 Bq/cm^{3} for ^{3}H in the air. The ratios of the detection limits to the regulation limits are less than 2.20E-02.

Table 3 Comparison of detection and regulation limits of the radioisotope concentration in the air.

Nuclides	Devices installed	Detection limit (Bq/cm^{3})	Detection limit/ legal limit
^{3}H	Tritium gas monitor	1.10E-02	2.20E-02
^{3}H	HC sampler and Liquid scintillation counting system	5.80E-05	2.90E-05
^{14}C		8.00E-06	2.00E-04
^{32}P	Dust sampler and Liquid scintillation counting system	3.80E-06	5.43E-04
^{35}S		2.00E-06	1.00E-04
^{60}Co	Dust sampler and Ge-spectroscopy system	5.60E-07	5.60E-04
^{131}I		1.68E-06	1.68E-03
^{137}Cs		5.60E-07	1.87E-04

The radioactivity of the ^{3}H and ^{14}C in the air is also measured using the HC air sampler and the liquid scintillation counting system. Assuming that the sampling air volume is 30 L and the measuring time is 10 min, the detection limits are 5.8E-5 Bq/cm^{3} and 8.0E-6 Bq/cm^{3} for ^{3}H and ^{14}C, respectively. The detection limits are smaller than the legal limits, and the ratios are 2.90E-05 and 2.00E-04 for ^{3}H and ^{14}C, respectively.

For monitoring radioisotope concentration of other nuclides in the air, two dust samplers can be used to collect the radioisotopes bound to the dust in the air. The filter papers in the dust samplers trap various radioisotopes, which are assumed to be ^{32}P, ^{35}S, ^{60}Co, ^{131}I, and ^{137}Cs. The radioactivity of ^{32}P and ^{35}S can be measured with the alpha/beta radiation measurement system, and those of ^{60}Co, ^{131}I, and ^{137}Cs can be measured with the germanium spectrometer. Assuming that the sampling volume of air is 900 L/30 min and the measurement time is approximately 4000 seconds, the detection limits of these measurements are estimated as shown in Table 3. The detection limits for ^{32}P and ^{35}S are 3.8E-6, and 2.00E-6 Bq/cm^{3}, respectively. In addition, the ratios of the detection limits to the regulation limits for ^{32}P and ^{35}S are 5.43E-04 and 1.00E-04, respectively. The detection limits of these measurements with the germanium spectrometer are 5.6E-7, 1.68E-6, and 5.6 E-7 Bq/cm^{3} and the ratios are 5.6E-4, 1.68E-3, and 1.87 E-4 for ^{60}Co, ^{131}I, and ^{137}Cs, respectively.

It is concluded that all apparatuses necessary for radiation monitoring can be compactly installed in an appropriately sized monitoring cart and that the cart has detection capability sufficient for radiation monitoring in a radiation workplace.