Radiological Consideration Regarding Logistical Management of Radioactive Surface Contamination After Fukushima Nuclear Accident

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1. Screening Implemented After the Fukushima Nuclear Accident

Before the Fukushima nuclear accident, screening levels were given as the indicator of the adoption of stable iodine, and it was determined on the basis of the equivalent dose of 100 mSv for pediatric thyroid. However, the Fukushima nuclear accident triggered by natural disaster (i.e., earthquake and tsunami) led to conditions where lifelines and essential materials for decontamination became unavailable for a long time owing to the extensive damage in wide disaster areas.

The screening levels were changed from 13,000 cpm to 100,000 cpm, which is the maximum range of the typical GM survey meter with a 5cm bore (**Photo**). Most of the 245,464 people were under 100,000 cpm as of 29 February 2012, and 102 people exceeded in the early phase of the accident.

Here we calculated the dose that may arise from handling objects contaminated at the level of the screening levels. The radiological consideration is also described from the viewpoint of intervention exemption and reference levels in emergency and existing exposure situations.

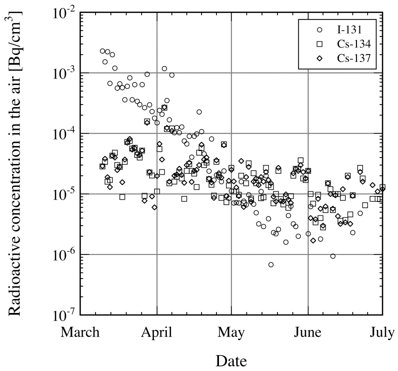

Figure 1 Radioactive concentration in the air observed at the site of Fukushima

2. Dose Assessment for Screening Levels for Decontamination

The isotope-specific surface contamination densities were calculated by total count rates of GM survey meter (100,000 cpm) and measurement result of radioactive concentration of I-131, Cs-134, and Cs-137 (**Figure 1**). The surface contamination densities were assumed in 5 cases. The annual dose that may arise from handling objects contaminated at the level of the screening levels were calculated (**Table 1**) by using the dose conversion factors developed in the previous studies. The skin-absorbed dose that arises from the direct deposition was also calculated by using the conversion factors of the skin-absorbed dose rate to the basal layer of the epidermis for beta and gamma irradiation given in Radiation Protection 65 of Commission of the European Communities (**Figure 2**).

Since 16 September 2011, the screening level for decontamination has decreased to 13,000 cpm; the final dose that may arise can be assumed to be lower than the numerical values given in **Table 1**. From the viewpoint of optimization of radiation protection using the basic concept of ALARA, in the long-term objectives, the screening levels for logistical management should be gradually lowered to the surface contamination criteria used under normal conditions and in planned exposure situations, which correspond to 4 Bq cm^{-2} for non alpha emitters, considering the status and social circumstances surrounding the residual contamination.

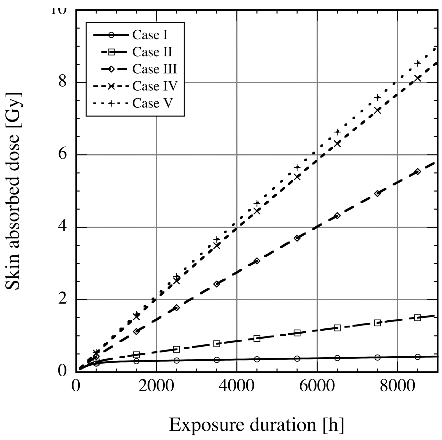

Figure 2. Skin-absorbed dose from direct deposition on body as a function of exposure duration

Table 1. Dose assessment at screening levels for decontamination (100,000 cpm) implemented after the Fukushima Nuclear Accident

Ratio of radionuclides (I-131 : Cs-134 : Cs-137)			Case I 100:1:1	Case II 10:1:1	Case III 1:1:1	Case IV 0.1:1:1	Case V 0.01:1:1
Surface contamination density [Bq cm^{-2}]		I-131	410	360	150	23	2.4
		Cs-134	4.1	3.6	150	230	240
		Cs-137	4.1	3.6	150	230	240
Objects	Manual [0.1 m^2]	Ingestion [mSv y^{-1}]	0.5	0.44	0.24	0.11	0.085
		Skin [mGy y^{-1}]	1.7	13	56	83	87
	Close [1 m^2]	External [mSv y^{-1}]	0.041	0.11	0.35	0.51	0.53
		Inhalation [mSv y^{-1}]	0.00076	0.00099	0.0019	0.0024	0.0025
	Remote [10 m^2]	External [mSv y^{-1}]	0.028	0.058	0.17	0.24	0.25
		Inhalation [mSv y^{-1}]	0.00011	0.00015	0.00028	0.00036	0.00038
Direct deposition to skin		Skin [mGy h^{-1}]	1.0	1.0	1.1	1.1	1.1

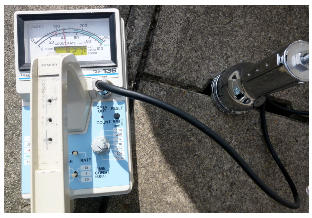

Photo
Typical GM Survey Meter Used for the Screening (Aloka Type TGS-136)

3. Radiological Consideration Regarding Logistical Management

The ICRP mentions in Publication 111 on the protection of people living in long-term contaminated areas after a nuclear accident or a radiation emergency that the reference level for optimizing the protection of people living in contaminated areas should be selected from the lower part of the 1-20 mSv y^{-1} band recommended in Publication 103 for the management of this category of exposure situation, and that past experience has demonstrated that a typical value used for constraining the optimization process in long-term post accident situations is 1 mSv y^{-1}. The ICRP also mentions in Publication 82 on the protection of the public in situations of prolonged radiation exposure that an intervention in the supply of commodities is exempted if the additional annual dose is approximately 1 mSv y^{-1}. Furthermore, the ICRP also mentions in Publication 104 that exemption or exclusion for naturally occurring radioactive material (NORM) -based industries could be handled with an individual dose criterion of approximately 1 mSv y^{-1} excluding the dose from radon. In this context, the additional annual dose of approximately 1 mSv y^{-1} can be considered as the intervention exemption level.

Considering the result of dose assessment for handled objects contaminated at the same level as the screening level for decontamination, it was found that the calculated annual effective doses in all cases are lower than the intervention exemption level.

Appropriate logistical management can also prevent reputational damage and discrimination rooted in the fear of the spread of contamination. There has been high social concern about the surface contamination on the human body, especially evacuees from Fukushima prefecture. However, screening to prevent the spread of contamination can also disturb the movement of people and goods in affected areas, which can lead to interference in evacuation, accident response, and recovery work. Thus, the screening should be applied with proper consideration of the overall status of the implementation of other protective countermeasures.

Overall verification of screening examination implemented after Fukushima nuclear accident and lessons learned should lead to an improved nuclear emergency preparedness and response all over the world.

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Reference: H. Ogino, T. Ichiji and T. Hattori, Verification of Screening Level for Decontamination Implemented After Fukushima Nuclear Accident, Radiation Protection Dosimetry (2012), in press, Available at: http://rpd.oxfordjournals.org/content/early/2012/01/06/rpd.ncr450.full (Open Access)