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Estimation of dust concentration at work places for decontamination waste disposal and selection of a respirator

1) Standardization of a worker's respiratory volume

Assume that the respiratory volume of an adult worker under an average work intensity is 30 L/min.

The respiratory volume per hour would be 1.8 m^3/h.

When the worker works for 8 hours a day, 250 days a year, then the worker's respiration time in the work environment would be 2000 hours/year.

2) Measured air-borne dust concentration

Figure 1 (Ref. (1)) shows the geometric mean of the air-borne dust concentration per unit workplace (the geometric mean of dust concentration at more than 5 locations in the unit workplace – measured value A) measured at 2579 locations in mineral dust generating workplaces. It shows the concentration range that had the highest occurrence ratio was 0.2 to 0.5 mg/m^3 while the highest concentration was in the range of 5.0 to 10 mg/m^3. Since those measured values are the geometric mean of the concentration measured at indoor workplaces that generate dust, they are not the highest dust concentration in the workplaces.

Meanwhile, Figure 2 shows the dust concentration measured near the dust source in the same workplaces, which is anticipated to have the highest dust concentration (measured value B). It shows that the concentration range with the highest occurrence ratio was 0.2 to 0.5 mg/m^3 while the highest concentration was in the range of 50 to 100 mg/m^3.

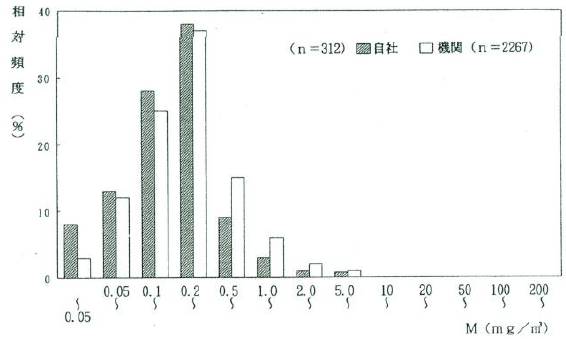

Figure 1: Measured values of working environment at 2579 locations in mineral dust workplaces (Measured value A geometric mean)

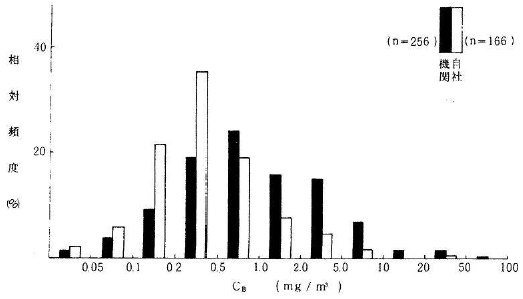

Figure 2: Values measured near the dust source at 422 locations of mineral dust workplaces (Measured value B)

Table 1 is the dust concentration exposure for individual workers, which Dr. Kikuji Kimura measured using the T-R Sampler for workers at a stone cutting and grinding factory (Ref. (2)). The T-R Sampler measures two types of dust (total dust and respirable dust) simultaneously when collecting air-borne dust on the filter. The boundary of the particle size of the respirable dust in the total dust is the 7 μm particle diameter where the filtration efficiency is 50% and it has the characteristic to change gradually around the boundary.

Table 1: Measured dust concentration exposure for individual workers during dry grinding work

Measurement method	Worker No.	Total dust concentration (mg/m^3)	Respirable dust concentration (mg/m^3)
T-R Sampler	1	12.0	1.7
	2	2.9	1.3
	3	34.6	10.6
	4	1.7	0.2
	5	32.3	9.1
	6	30.3	8.7
	7	28.0	5.2
	8	3.9	0.9
	9	2.1	1.2
	10	9.1	2.7

Based on the above data sets, it will be reasonable to assume for the prevention of dust exposure at work in general that the maximum air-borne dust concentration (respirable particles) is 100 mg/m^3 at workplaces where

workers are manually handling incineration ashes that are prone to generate dust; the concentration commonly encountered is 30 mg/m^3 or less; and the concentration range occurring as the weighted mean concentration during work hours is 10 mg/m^3 or less.

Meanwhile, measurement of the dust concentration at 20 work locations inside and outside the incineration facility was also reported (Ref. (3)). The dust concentration data in this report have already been presented in Material 7 of the "2nd Expert Meeting on Radiological Protection for Disposal Works of Decontamination-Removed Materials". According to the result, the highest dust concentration in the incineration facility was detected at the small-scale mechanical batch furnace to burn industrial waste, and the detected value was 13.19 mg/m^3 (when all air-borne dust particles were collected with a high-volume sampler). Other works in the incineration facility that generate high concentration dust included the soot and dust treatment, removal of incombustibles, adjustment of the burner, and work to handle bulk wastes; and the maximum concentration of air-borne dust detected was 3.5 mg/m^3. However, here, the quantity of dust was measured by continuously suctioning the air-borne dust at the site for a certain period of time using a high-volume sampler equipped with a HEPA filter, which is the weighted mean of the time and space, and does not reflect the spontaneous peak concentration of the dust.

3) Estimation of radioactive dust concentration exposure for workers who are engaged in disposal works of decontamination-removed materials

The level of exposure to the dust containing radioactive materials for workers engaged in various works at the incineration facility was estimated, and the protection factors required for the respiratory protection device to prevent the intake of the dust was calculated. The results are shown in Attachment 1.

The following assumptions were set for estimating the quantity of radioactive materials that workers got via inhalation of the air-borne dust, and then based on the estimates, the protection factor was calculated for the respiratory protection equipment.

(1) The following three levels were set for dust concentration in the air

100 mg/m^3: The maximum dust concentration exposure at works that manually and directly handle decontamination wastes or incineration ashes and soot, which are prone to generate dust, or the works performed in their vicinity.

30 mg/m^3: The maximum dust concentration exposure at works that manually handle decontamination wastes during their transportation, delivery, sorting, and cleaning, or the works performed in their vicinity.

10 mg/m^3: The upper limit of the weighted mean for the time and space for the concentration of the dust generated at the locations where transportation, delivery, sorting and cleaning of the decontaminated waste are regularly performed.

(2) The respiration rate is standardized at 30 L/min.

The respiration rate varies depending on the work intensity and the physical size of an individual. 30 L/min is the rate of respiration when engaging in general work of light intensity, and does not reflect any particularly

heavy labour. Therefore, when selecting the respiratory protective equipment, it is desirable to stay on the safe side on the calculated value of the protective factor.

(3) The dust generated from the decontamination waste contains miscellaneous materials that are generated from soil, plants, and debris of collapsed houses, thus respiratory protection against these materials needs to be considered as well. However, Attachment 1 is based on radioactive materials (Cs-134 and Cs-137) contained in the waste. Therefore, even in cases where the inhalation level of the radioactive materials is low, it may also be necessary to consider respiratory protection against other materials in the dust.

References

1: “Management of the work environment measurement accuracy”, Japan Association for Working Environment Measurement (1989)

2: Kikuji Kimura, “Dust concentration exposure to workers in stone cutting and grinding factory” (personal note)

3: “Report by a study committee on the current status of the exposure of workers to dioxins in the cleaning industries (1999 to 2001)” Japan Industrial Safety & Health Association, Industrial Health Inspection Center

Attachment 1: Classification of work in the incineration facility and type of protection device selected for the work – 2nd draft

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Assumed work	Concentration of radioactive materials in dust	Dust concentration	Dust inhalation /h	Intake of radioactive materials /h	Committed dose/h	Committed dose /y	Goal for the committed dose control /y	Required protection factor for respiratory protection	Types of respiratory protective equipment (Taking into consideration breathing quantity and mineral dust, etc.)
Unit (conversion factor)	Bq/kg	mg/m^3	mg/h ($1.8\ m^3/h$)	Bq/h	mSv/h (8.15×10^{-6} mSv/Bq)	mSv/y (250 days×8h =2,000h)	mSv/y		
Handling of ashes/soot	10,000,000	100	180	1800	14670×10^{-6}	29.3	5	5.9	Half-face mask, Full-face mask, Powered equipped
							1	29.3	Full-face mask, Powered equipped
		30	54	540	4401×10^{-6}	8.8	5	1.8	Half-face mask, Full-face mask, Powered equipped
							1	8.8	Full-face mask, Powered equipped
		10	18	180	1467×10^{-6}	2.9	5	<1	Disposable, Half-face mask
							1	2.9	Half-face mask, Full-face mask, Powered equipped
Handling of ashes, soot and wastes	5,000,000	100	180	900	7335×10^{-6}	14.7	5	2.9	Half-face mask, Full-face mask, Powered equipped
							1	14.7	Full-face mask, Powered equipped
		30	54	270	2201×10^{-6}	4.4	5	<1	Disposable, Half-face mask
							1	4.4	Half-face mask, Full-face mask, Powered equipped
		10	18	90	734×10^{-6}	1.5	5	<1	Disposable, Half-face mask
							1	1.5	Half-face mask, Full-face mask, Powered equipped
Handling of wastes	2,000,000	100	180	360	2930×10^{-6}	5.9	5	1.2	Half-face mask, Full-face mask, Powered equipped
							1	5.9	Half-face mask, Full-face mask, Powered equipped
		30	54	108	879×10^{-6}	1.8	5	<1	Disposable, Half-face mask
							1	1.8	Half-face mask, Full-face mask, Powered equipped
		10	18	36	293×10^{-6}	0.59	5	<1	Disposable
							1	<1	Disposable, Half-face mask
Handling of wastes	1,000,000	100	180	180	1467×10^{-6}	2.9	5	<1	Disposable, Half-face mask
							1	2.9	Disposable, Half-face mask
		30	54	54	440×10^{-6}	0.88	5	<1	Disposable
							1	<1	Disposable
		10	18	18	147×10^{-6}	0.29	5	<1	Disposable
							1	<1	Disposable
Handling of wastes	500,000	100	180	90	733×10^{-6}	0.59	5	<1	Disposable
							1	<1	Disposable
		30	54	27	220×10^{-6}	0.18	5	<1	Disposable
							1	<1	Disposable
		10	18	9	73×10^{-6}	0.06	5	<1	Disposable
							1	<1	Disposable