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Vehicle surface contamination intervention levels for conducting checks on international traffic pursuant to the Precautionary Radiation Protection Act

Recommendation by the German Commission on Radiological Protection

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Empfehlung der Strahlenschutzkommission

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In the event of any doubts about the meaning, the German original as published shall prevail.

Contents

1 Introduction

Vehicle surface contamination intervention levels in the event of incidents involving possible, not inconsiderable radiological implications can be fixed in accordance with the Precautionary Radiation Protection Act (Strahlenschutzvorsorgegesetz, StrVG). The measuring procedures are described in DIN 25700 "Surface contamination measurements on vehicles and vehicle loads in exceptional situations having a bearing upon radiation protection" and serve the purpose of checking the observation of intervention levels valid in an exceptional situation.

The recommendation below is intended to provide advice on fixing contamination values pursuant to § 6 of the Precautionary Radiation Protection Act and the application of such values within the framework of § 8 of the Precautionary Radiation Protection Act. In accordance with this Act, for example, vehicle decontamination measures may be ordered at the border and persons advised of preventive health protection measures. This recommendation does not address the issue as to whether or not it is possible to refuse affected persons travelling in private cars permission to cross the border on the grounds that the contamination intervention levels are exceeded.

2 Recommendation

A value of **1 kBq/cm^2** related to a nuclide mixture which is typical of nuclear incidents and accidents and which corresponds to the assumptions for release category 4 of Phase A of the German Risk Study (see attachment 2) is proposed as an intervention level for measures in the case of vehicle surface contamination in the event of incidents involving possible, not inconsiderable radiological implications. This intervention level equates to a gamma dose rate of approximately 5 µSv/h at a distance of one meter from a vehicle, a dose which, in terms of measuring technology, can be established without problem also by auxiliary personnel. This intervention level applies to the above-mentioned nuclide mixture. In the case of deviations, other contamination values can be fixed.

In the event of the intervention level for vehicles being exceeded, the vehicle in question should be subjected to decontamination measures. In this case, the vehicle passengers should be informed about any possible hazards.

3 Justification

In the case of a measuring instruction to be elaborated in accordance with DIN 25700 for determining vehicle contamination, only surface contamination is observed. Due to the minimal bearing which vehicle type has on the measuring result, no differentiation between different vehicle types is necessary. Similarly, in consequence of the direct measuring procedures which primarily enter into consideration (determination of contamination by means of measuring the gamma radiation), no distinction is made between adhesive and non-adhesive contamination in the estimations presented below.

This recommendation on establishing an intervention level considers the possible risk to persons in the vehicles and at the destination of these vehicles due to direct radiation and incorporation. According to Table 1, Appendix D of Volume 13, 2nd revised edition of the Publications of the Commission on Radiological Protection, a decontamination is recommended, if the contamination of the skin exceeds the limit of 0.4 to 4 kBq/cm^2. A contamination of skin and clothing with 0.4 kBq/cm^2 of a nuclide mixture which is typical in the case of nuclear incidents and accidents and which corresponds to the assumptions for release category 4 of Phase A of the German Risk Study results within twenty-four hours in a ß-skin dose of 10 mSv and a bone marrow dose of 0.2 mS. α-emitters are of no consequence in this nuclide mixture.

The recommendation of the intervention level of 1 kBq/cm^2 for contaminated vehicles is derived from this intervention level for skin contamination. In this context, it is assumed that the contamination of vehicles and of the skin of passengers may be in the same order of magnitude.

For persons who spend 1000 hours in their vehicle during the first six months after contamination, the external radiation dose rate due to vehicle contamination remains below 2 mSv. Persons located within a 1 m radius of a vehicle receive an effective dose of below 0.2 mSv. A stay of two hours per day in the vicinity of a contaminated vehicle during the first six months was assumed.

The incorporation dose totals less than 0.1 mSv during the first six months if it is assumed that the activity remaining on the contaminated surface of approximately 1 cm^2 is incorporated per day.

The doses given above have been calculated according to the equations in attachment 1.

The recommendation of the intervention level left cargo out of account. Here other intervention levels or limits (e.g. for foodstuffs) apply. The radiation from contaminated vehicle air filters is also disregarded.

Contamination levels equating to the index level of 1 kBq/cm^2 recommended for vehicles may easily be detected at inspection points by trained fire service and catastrophe prevention service personnel by means of direct γ-radiation measurements. At a contamination level of 1 kBq/cm^2, for a typical nuclide mixture according to the assumptions for release category 4 of the German Nuclear Power Stations Risk Study, Phase A, the dose at a distance of 1 m from vehicles is approximately 5 μSv/h.

Attachment 1: Estimation of doses resulting from vehicle contamination

1 Calculation of the external dose for vehicle drivers

In the case of a typical nuclide mixture according to release category 4 of the German Nuclear Power Stations Risk Study, Phase A, in the first thirty days the half-life period is approximately 7.7 d, thereafter 106 d. The average photon dose rate constant for this nuclide mixture [Mis 94, SSK 95] has the value $\Gamma = 140$ (fSv/h)/(Bq/m^2). At the centre of a sphere with a surface contamination of A_F, follows for the dose rate:

$$\dot{H}(t) = \Gamma \cdot \frac{A_F(t)}{r^2} \cdot 4\pi r^2 = 4\pi\Gamma A_F(t)$$

and

$$A_F(t) = A_F(T=0) \cdot \exp(-t \cdot \ln 2 / T_{½})$$

$T_{½}$ is 7.66 d and 106 d respectively.

Accordingly, the dose is calculated as

$$H = \int_0^{30} \dot{H}_{30}(t)dt + \int_{30}^{180} \dot{H}_{180}(t)dt$$

In the case of a working time of forty hours per week, the value obtained needs multiplying by the "duty factor" F=40h/(7×24 h).

2 Calculation of the external dose for persons in the vicinity of vehicles

At a distance of 1 m from a vehicle with the contamination level $A_F=10^7$ Bq/m^2, in accordance with DIN 25700 [DIN 95], Fig. 2, the dose rate totals approximately 5 µSv/h. Similar to the calculations under 1 above, the dose is determined on the basis of the sum of the two integrals for the first thirty days and the remainder.

Assuming an random daily stay of two hours in the vicinity of such vehicles, the value needs multiplying by a duty factor of F=2h/24h.

3 Estimation of the incorporation dose

Dunster [Dun 64] assumes that every day workers incorporate the activity which is located on 10 cm^2 of their skin. This assumption of the daily incorporation of contamination located in an area of 10 cm^2 is also made in respect of the calculation of intervention levels [Hun 83] for other surface contamination. With regard to the typical radioactive fission product mixture [Mis 94], the dose factor for incorporation is approximately F_I = 5 nSv/Bq. Assuming that this activity is also incorporated from the surface of a vehicle, the consequential dose is calculated by

$$H = F_I \cdot 10\text{cm}^2 \cdot \left[\int_0^{30} A_F(t)dt + \int_{30}^{180} A_F(t)dt \right].$$

Since the assumption of 10 cm^2 relates to the work environment, a duty factor of F = 1/10 is assumed here; this also relativizes the possibly excessively conservative above-mentioned assumption.

4 Consideration of natural decontamination

Pilwat et al. [Pil 92] report that after around 300 mm of rain, activity on paving stones is reduced by half. Assuming an annual rainfall rate of 600 mm, this gives a natural decontamination half-life value of approximately 180 days.

No typical half-life periods for natural decontamination of lacquered surfaces are available. However, half-life periods for natural decontamination of T_{decon} = 80 d (according to Schwarz and Brenk [Sch 85]) are reported for various surfaces.

The ensuing effective half-life periods and resulting reduced dose values are contained in columns 3 and 4 of the results table (next page). There is no significant change compared to calculations for 180 days.

	Physical decay	**T_{decon} = 180 d**	**T_{decon} = 80 d**
Average half-life period 30 d*)	7.66	7.35	6.73
Average half-life period 180 d*)	106.00	66.71	36.38
A_F (0d) (Bq/m^2)	1.00E+07	1.00E+07	1.00E+07
A_F (30d) (Bq/m^2)	6.63E+05	5.90E+05	4.55E+05
$\dot{H}$ (sphere, 0d) (µSv/h)	17.59	17.59	17.59
$\dot{H}$ (sphere, 30d) (µSv/h)	1.17	1.04	0.80
H (sphere, 0d-30d) (mSv)	4.36	4.21	3.91
H (sphere, 30d-180d) (mSv)	2.68	1.89	0.95
H (sphere, 0d-180d) (mSv)	7.03	6.10	4.86
Duty factor (40h/week)	0.24	0.24	0.24
H (HGV drivers) (mSv)	**1.67**	**1.45**	**1.16**
$\dot{H}$ (passer-by, 0d) (µSv/h)	5.00	5.00	5.00
$\dot{H}$ (passer-by, 30d) (µSv/h)	0.33	0.30	0.23
H (passer-by, 30d) (mSv)	1.24	1.20	1.11
H (passer-by, 30d-180d) (mSv)	0.76	0.54	0.27
H (passer-by, 0d-180d) (mSv)	2.00	1.73	1.38
Duty factor (2h/24h)	0.08	0.08	0.08
H (passer-by) (mSv)	**0.17**	**0.14**	**0.12**
H (incorporation, 0d-30d) (mSv)	0.52	0.53	0.49
H (incorporation, 30d-180d) (mSv)	0.32	0.22	0.11
H (incorporation, 0d-180d) (mSv)	0.83	0.75	0.60
Duty factor: 1/10	0.10	0.10	0.10
H (incorporation) (mSv)	**0.08**	**0.08**	**0.06**

*) average half-life period in the first thirty and 180 days

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[Sch 85] Schwarz, G.: Deposition and Post-Deposition Behaviour of off-site Radiological Consequences of Nuclear Accidents (Proceed.), Luxembourg (Apr. 1985). Commission of the European Communities, EUR 10397 (1986)

Attachment 2: Release category RC 4

Extract from: Tabelle F8, 3-2 Freisetzungskategorien der Deutschen Risikostudie Phase A, Fachband 8, Verlag TÜV Rheinland, Köln, 1981

Release category (RC) No.	**Description**	**Time of release h**	**Duration h**	**Release height m**	**Released energy 10^6/kJ/h**	**Release frequency 1/a**
4	Nuclear meltdown, small leak in the safety container (∅ 25 mm)	2	3	10	-	3×10^{-6}

Released proportion of the nuclear inventory							
Xe-Kr	J_{org}	J_2-Br	Cs-Rb	Te-Sb	Ba-Sr	Ru[2)]	La[3)]
1.0	7.0×10^{-3}	1.5×10^{-2}	5.1×10^{-3}	5.0×10^{-3}	5.7×10^{-4}	4.0×10^{-4}	6.5×10^{-5}

[2)] contains Ru, Rh, Co, Mo, Tc
[3)] contains Y, La, Zr, Nb, Ce, Pr, Nd, Np, Pu, Am, Cm