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On the Specification of Limits of Radioactivity in Feedstuffs in the Case of a Nuclear Accident or other Radiological Emergency

Recommendation of the German Commission on Radiological Protection

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Zur Festlegung von Höchstwerten an Radioaktivität in Futtermitteln im Falle eines nuklearen Unfalls oder einer anderen radiologischen Notfallsituation

Empfehlung der Strahlenschutzkommission

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

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1 Introduction

On 10 December 1987 the Commission on Radiological Protection (Strahlenschutzkommission, SSK) was asked by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) to develop proposals for the definition of limit values for specific activity in feedstuffs which were to supplement the appendix of EC Regulation No. 3954/87 which had by then entered into force. The above-mentioned EC Regulation establishes the procedure for defining limit values of radioactivity in foodstuffs or feedstuffs which might be marketed in the aftermath of a nuclear accident or any other radiological emergency which may cause or have caused considerable radioactive contamination of foodstuffs or feedstuffs. The limit values of specific activity in feedstuffs must be defined in such a way as to avoid the limit values of specific activity or activity concentration in foodstuffs being exceeded under normal feeding conditions. In addition, the SSK and the BMU expressed the desire to also list measures which lead to reduced contamination, especially of regionally produced fresh feedstuffs, and to take them into account in the general concept.

The committee “Radioecology” was instructed by the SSK to develop an appropriate proposal for the definition of limit values of radioactivity in feedstuffs. The committee created a preparatory group to perform this task.

In particular, the group dealt with the following subjects:

a) problems of defining the maximum daily admissible intake of radionuclides by productive livestock so that the contamination limits for foodstuffs of animal origin listed in the EC Regulation No. 3954/97 of 22 December 1987 are not exceeded,

b) possible actions to keep the contamination of feedstuffs and of foodstuffs of animal origin produced with such feedstuffs as low as appropriately possible, with a given contamination of the environment, and

c) problems connected with the definition of limit values of radioactivity in feedstuffs.

2 Basis for the Definition of Limit Values of Radioactivity in Feedstuffs

The radioactivity in foodstuffs of animal origin resulting from consumed contaminated feedstuffs depends both on the type of animal and the production and on time. The level of contamination is determined by the rate of fed activity (i.e. the radioactivity “fed” to the individual animal every day via the contaminated feedstuffs) and the transfer factor (activity of the foodstuffs of animal origin, referring to the rate of fed activity). With given limit values of radioactivity in foodstuffs of animal origin and with specific transfer factors the maximum daily rate of fed activity is defined if the animals are consistently fed with the same amount of contaminated feedstuffs. Tables 1 to 5 specify the transfer factors which are used to estimate the maximum admissible rates of fed activity to productive livestock which are necessary in order to comply with the defined values of radioactivity for the most important foodstuffs of animal origin and for the radionuclides mentioned in the EC Regulation No. 3954/8.

The EC limit values (column 4 of the tables) will probably not be exceeded for those foodstuffs of animal origin which are listed in column 1 and produced under the conditions that prevail in the field of animal production in the Federal Republic of Germany and Berlin (West) if the maximum amounts of Cs 137/134, Sr 90, I 131, Am 241 and Pu 239 given in column 5 of Tables 1 to 5 are complied, with and if the contamination of the feedstuffs remain consistent during the entire fattening period. Transfer factors used for these estimates are listed in column 2, representative sources thereof in column 3 and the approximate period of time (in days) to reach 90 % of the equilibrium values (here limit values) in column 6.

With chronic feeding the limit values for the specific activity of feedstuffs can be calculated formally from the maximum daily amount taken in by the animals, if the so called amounts of complete feed (i.e. the daily rations) are known. Table 6 lists the amounts of complete feed for individual types of animals.

Table 1: Estimates of the maximum permissible amount of Cs 137 chronically taken in by productive livestock in order to keep given limit values for foodstuffs of animal origin

foodstuff of animal origin	transfer factor d/l, d/kg	source for transfer factors	limit value Bq/l, Bq/kg	max. feed Bq/d	90% of equilibrium after d
cow's milk	0,005	/ABG 88/	1000	$2,0 \cdot 10^5$	10
ewe's milk	0,06	/GSF/BLT 86/87/	1000	$1,6 \cdot 10^4$	10
goat's milk	0,06	/Was 61/	1000	$1,6 \cdot 10^4$	10
cow's meat	0,03	/ABG 88/	1250	$4,1 \cdot 10^4$	90
feeder cattle meat	0,03	/ABG 88/	1250	$4,1 \cdot 10^4$	150
veal	0,4	/GSF/BLT 86/87/	1250	$3,1 \cdot 10^3$	90
fattened pig meat	0,4	/GSF/BLT 86/87/	1250	$3,1 \cdot 10^3$	100
mutton/goat meat	0,15	/Fli 80/	1250	$8,3 \cdot 10^3$	120
lamb	0,6	/May 87/	1250	$2,0 \cdot 10^3$	60
chicken meat	4,5	/Ng 82/	1250	$2,7 \cdot 10^2$	60
hen's eggs	0,2	/GSF/BLT 88/	1250	$6,2 \cdot 10^3$	30

Table 2: Estimates of the maximum permissible amount of Sr 90 chronically taken in by productive livestock in order to keep given limit values for foodstuffs of animal origin

foodstuff of animal origin	transfer factor d/l, d/kg	source for transfer factors	limit value Bq/l, Bq/kg	max. feed Bq/d	90% of equilibrium after d
cow's milk	$2{,}0 \cdot 10^{-3}$	/ABG 88/	125	$6{,}2 \cdot 10^{4}$	10
ewe's milk	$1{,}4 \cdot 10^{-2}$	/Sco 66/	125	$8{,}9 \cdot 10^{3}$	10
goat's milk	$1{,}4 \cdot 10^{-2}$	/Sco 66/	125	$8{,}9 \cdot 10^{3}$	10
cow's meat	$6{,}0 \cdot 10^{-4}$	/ABG 88/	750	$1{,}2 \cdot 10^{6}$	20
feeder cattle meat	$6{,}0 \cdot 10^{-4}$	/ABG 88/	750	$1{,}2 \cdot 10^{6}$	20
veal	$2{,}0 \cdot 10^{-3}$	/Mül 82/	750	$3{,}7 \cdot 10^{5}$	20
fattend pig meat	$2{,}0 \cdot 10^{-3}$	/Wag 84/	750	$3{,}7 \cdot 10^{5}$	20
mutton/goat meat	$3{,}0 \cdot 10^{-3}$	/Fli 81	750	$2{,}5 \cdot 10^{5}$	
lamb	$3{,}0 \cdot 10^{-3}$	/Ng 82/	750	$2{,}5 \cdot 10^{5}$	20
chicken meat	$3{,}5 \cdot 10^{-2}$	/Ng 82/	750	$2{,}1 \cdot 10^{4}$	5
hen's eggs	$3{,}0 \cdot 10^{-1}$	/Ng 82/	750	$2{,}5 \cdot 10^{3}$	20

Table 3: Estimates of the maximum permissible amount of I 131 chronically taken in by productive livestock in order to keep given limit values for foodstuffs of animal origin

foodstuff of animal origin	transfer factor d/l, d/kg	source for transfer factors	limit value Bq/l, Bq/kg	max. feed Bq/d	90% of equilibrium after d
cow's milk	0,003	/ABG 88/	500	$1{,}6 \cdot 10^{5}$	3
ewe's milk	0,2	*	500	$2{,}5 \cdot 10^{3}$	3
goat's milk	0,2	*	500	$2{,}5 \cdot 10^{3}$	3
cow's milk	0,004	/ABG 88/	2000	$5{,}0 \cdot 10^{5}$	20
feeder cattle meat	0,004	/ABG 88/	2000	$5{,}0 \cdot 10^{5}$	20
veal	0,003	GSF (calc.)	2000	$6{,}6 \cdot 10^{5}$	20
fattend pig meat	0,003	GSF (calc.)	2000	$6{,}5 \cdot 10^{5}$	20
mutton/goat meat	0,003	GSF (calc.)	2000	$6{,}6 \cdot 10^{5}$	20
lamb	0,01	GSF (calc.)	2000	$2{,}0 \cdot 10^{5}$	20
chicken meat	0,02	/Ng 82/	2000	$2{,}0 \cdot 10^{5}$	20
hen's eggs	2,8	/Ng 82/	2000	$7{,}1 \cdot 10^{2}$	20

* Estimated on the basis of the contamination of milk after Chernobyl, multiplied by the factor 10, despite an amount of fodder reduced by the factor 7, compared with cows

Table 4: Estimates of the maximum permissible amount of Am 241 chronically taken in by productive livestock in order to keep given limit values for foodstuffs of animal origin

foodstuff of animal origin	transferfactor d/l, d/kg	source for transfer factors	limit value Bq/l, Bq/kg	max. feed Bq/d	90% of equilibrium after d
cow's milk ewe's milk	$2{,}0 \cdot 10^{-5}$	/ABG 88/	20	$1{,}0 \cdot 10^{6}$	
goat's milk	$4{,}0 \cdot 10^{-6}$	/IAEA 87/		$5{,}0 \cdot 10^{6}$	
cow's meat	$4{,}0 \cdot 10^{-6}$	/ABG 88/	80	$2{,}0 \cdot 10^{7}$	
feeder cattle meat veal	$4{,}0 \cdot 10^{-6}$	/ABG 88/	80	$2{,}0 \cdot 10^{7}$	
fattend pig meat lamb	$4{,}0 \cdot 10^{-5}$	/Cou 84/*	80	$2{,}0 \cdot 10^{6}$	
chicken meat	$2{,}0 \cdot 10^{-4}$	/Ng 82/	80	$4{,}0 \cdot 10^{5}$	
hen's eggs	$9{,}0 \cdot 10^{-3}$	/Ng 82/	80	$8{,}8 \cdot 10^{3}$	

* Calculated on the basis of the model and data from /Cou 84/

Table 5: Estimates of the maximum permissible amount of Pu 239 chronically taken in by productive livestock in order to keep given limit values for foodstuffs of animal origin

foodstuff of animal origin	transfer factor d/l, d/kg	source for transfer factors	limit value Bq/l, Bq/kg	max. feed Bq/d	90% of equilibrium after d
cow's milk ewe's milk goat's milk	$1{,}0 \cdot 10^{-7}$	/ABG 88/	20	$2{,}0 \cdot 10^{8}$	
cow's meat	$2{,}0 \cdot 10^{-6}$	/ABG 88/	80	$4{,}0 \cdot 10^{7}$	
feeder cattle meat veal	$2{,}0 \cdot 10^{-6}$	/ABG 88/	80	$4{,}0 \cdot 10^{7}$	
fattened pif meat	$2{,}0 \cdot 10^{-5}$	/Cou 84/*	80	$4{,}0 \cdot 10^{6}$	
mutton/goat meat lamb	$1{,}0 \cdot 10^{-4}$	/EG 87/	80	$8{,}0 \cdot 10^{5}$	
chicken meat	$1{,}6 \cdot 10^{-4}$	/Ng 82/	80	$5{,}0 \cdot 10^{6}$	
hen's egg	$8{,}0 \cdot 10^{-3}$	/Ng 82/	80	$1{,}0 \cdot 10^{4}$	

* Calculated on the basis of the model and data from Coughtrey (1984)

Table 6: Average daily amount of complete feed for different types of productive livestock

type of animal	amount of complete feed (dry matter)
dairy cow	16 kg/d
fattening cattle	8 kg/d
fattening calf	2 kg/d
sheep/goat	2 kg/d
lamb/kid	1.3 kg/d
fattening pig	2.5 kg/d
chicken	0.12 kg/d

3 Results

The values in Tables 1 to 5 and in Table 6 can be used to determine limit values of specific activity in complete feed (i.e. mixed feed which supposedly suffices to cover the feed requirements of the animals) for individual types of animals and their uses; these limit values would result in the limit values for radioactivity in foodstuffs of animal origin not being exceeded if such feedstuffs were fed to the animal over a long period of time. In addition, limit values can be calculated for individual feedstuffs, taking into account their main types of use. However, a whole range of different measures can be used on farms to greatly reduce (by the factor of 10) the contamination of feedstuffs and of foodstuffs of animal origin deriving therefrom. The SSK is of the opinion that in order to optimize the costbenefit relationship of protective measures and countermeasures in accordance with the recommendations of ICRP Report No. 26 it would neither be practical nor appropriate to specify in advance and without knowledge of the extent (level and geographie scope) of the contamination of the environment caused by a major nuclear accident limit values of specific activity in feedstuffs on the assumption of chronic feeding and without considering the measures in Table 7.

Furthermore, these measures represent only tertiary protective quantities preceded by the primary goal of protection against radiation “limitation of the exposure to radiation suffered by the population” and the secondary guiding value of intervention for the maximum permissible contamination of foodstuffs for human consumption derived therefrom. The situation should not be confused with the situation in the case of regulations for maximum amounts concerning chronic, longterm contamination of feedstuffs under normal environmental conditions (compared with the situation during normal operation of nuclear plants).

Table 7: Measures to reduce the contamination in foodstuffs of animal origin which should be evaluated in a given situation with respect to effectiveness and practicability

1	REDUCTION OF CONTAMINATION IN FEEDSTUFFS DURING PRODUCTION (CULTIVATION) AND HARVEST
1.1	Soil treatment and fertilization (f.e. influencing pH-value, K- and Ca-fertilizing; plouhing up)
1.2	Choice of point in time when products are to be used (reduction of short-lived activity, reduction of activity concentration by weathering and increase of biomass)
1.3	Adaption of harvesting procedures (f.e. different height of cutting)
1.4	Elimination of highly contaminated feedstuffs
2	REDUCTION OF CONTAMINATION IN FEEDSTUFFS DURING STORAGE AND PREPARATION OF FEEDSTUFFS
2.1	Protection of stored feedstuffs against contamination (f.e. cover forsilos)
2.2	Prolonged storage of feedstuffs (especially in the case of shortlived nuclides)
2.3	Decontamination of the surface (f.e. washing, peeling)
2.4	Chemo-physical treatment (f.e. addition of ion exchangers during the production of feedstuffs)
3	REDUCED INTAKE OF RADIONUCLIDES BY THE ANIMAL
3.1	Adaption of pasture management (turning out to/return from pasture)
3.2	Adaption of feed rations (mixture of feedstuffs with different degrees of contamination)
4	REDUCTION OF INTESTINAL ABSORPTION
4.1	Supply of minerals (f.e. restrictive use of iodine additives, increased supply of calcium)
4.2	Additional supply of ion exchangers (f.e. bentonite, iron-cyanoferrate complexes)
5	REDUCED CONTAMINATION OF FOODSTUFFS OF ANIMAL ORIGIN BY CHANGES IN PRODUCTION AND/OR IN FEEDING PROCEDURES
5.1	Different allocation of contaminated feedstuffs to individual animals or groups of animals (production plant, state of efficiency) (f.e. feed only in the beginning of fattening period)
6	REDUCED CONTAMINATION IN FOODSTUFFS OF ANIMAL ORIGIN
6.1	Prolonged storage (shortlived radionuclides)
6.2	Selective preparation (f.e. milk, fractionation, use of ion exchangers)

The SSK thus recommends that limit values of radioactivity in feedstuffs should not be defined.

If the definition of limit values cannot be avoided, however, the following points should be taken into consideration:

- A distinction must be made between feedstuffs which – for a certain type of animals and production – may be used without any restrictions for a longer period of time and feedstuffs which may only be used under certain conditions.
- The limit values for specific activity in feedstuffs which may be used under certain conditions should be ten times higher than the limit values for those complete feedstuffs which may be used without any restriction in time.

Reasons:

a) We cannot assume that only highly contaminated fodder will be used.

b) Appropriate advice for farmers can ensure that, taking into account the measures in Table 7, even the use of such higher contaminated feedstuffs will not lead to a situation where the limit values for radioactivity in foodstuffs of animal origin are exceeded.

- If the limit value is calculated from the quotient between the maximum daily amount of activity taken in by the animal and the amount of complete feed per day it should be determined for individual types of animals and groups of nuclides.
- It must be ensured that appropriate advice on the correct use of contaminated feedstuffs is given in good time in order to minimize contamination of foodstuffs of animal origin.
- Feedingstuff which may only be used under certain conditions should be labelled accordingly and should include information on restrictions for feeding.

Taking into account the above mentioned conditions and in view of the fact that the SSK was asked to make proposals in order to supplement the table in the appendix of EC Regulation 3954/87 of 22 December 1987, the SSK suggests that the BMU proposes the limit values for specific activity in feedstuffs during the deliberations at the EC which are listed in Table 8.

Table 8: Limit values of specific activity in complete feed for free trade, in Bq/kg dry matter (The lowest limit values for nuclides are underlined)

use	no restriction in time				with advice (under certain conditions)			
repres. radio-nuclide for group	Sr 90	I 131	Pu 239 Am 241	Cs 137	Sr 90	I 131	Pu 239 Am 241	Cs 137
animal and type of produktion								
milk cow	$\underline{3{,}9 \cdot 10^3}$	$1{,}0 \cdot 10^4$	$\underline{6{,}0 \cdot 10^4}$	$1{,}2 \cdot 10^4$	$\underline{3{,}9 \cdot 10^4}$	$1{,}0 \cdot 10^5$	$\underline{6{,}2 \cdot 10^5}$	$1{,}2 \cdot 10^5$
milk goat	$4{,}4 \cdot 10^3$	$\underline{1{,}2 \cdot 10^3}$	$2{,}5 \cdot 10^6$	$8{,}0 \cdot 10^3$	$4{,}4 \cdot 10^4$	$\underline{1{,}2 \cdot 10^4}$	$2{,}5 \cdot 10^7$	$8{,}0 \cdot 10^4$
milk sheep	$4{,}4 \cdot 10^3$	$\underline{1{,}2 \cdot 10^3}$	n. *	$8{,}0 \cdot 10^3$	$4{,}4 \cdot 10^4$	$\underline{1{,}2 \cdot 10^4}$	n. *	$8{,}0 \cdot 10^4$
cow (meat)	$7{,}5 \cdot 10^4$	$3{,}1 \cdot 10^4$	$1{,}2 \cdot 10^6$	$2{,}6 \cdot 10^3$	$7{,}5 \cdot 10^5$	$3{,}1 \cdot 10^5$	$1{,}2 \cdot 10^7$	$2{,}6 \cdot 10^4$
fattening cattle	$1{,}5 \cdot 10^5$	$6{,}2 \cdot 10^4$	$2{,}5 \cdot 10^6$	$5{,}2 \cdot 10^3$	$1{,}5 \cdot 10^6$	$6{,}2 \cdot 10^5$	$2{,}5 \cdot 10^7$	$5{,}2 \cdot 10^4$
fattening calf	$1{,}9 \cdot 10^5$	$3{,}3 \cdot 10^5$	n. *	$1{,}6 \cdot 10^3$	$1{,}9 \cdot 10^6$	$3{,}3 \cdot 10^6$	n. *	$1{,}6 \cdot 10^4$
fattening pig	$1{,}5 \cdot 10^5$	$2{,}6 \cdot 10^5$	$8{,}0 \cdot 10^5$	$\underline{1{,}2 \cdot 10^3}$	$1{,}5 \cdot 10^6$	$2{,}6 \cdot 10^6$	$8{,}0 \cdot 10^6$	$\underline{1{,}2 \cdot 10^4}$
sheep (meat)	$1{,}2 \cdot 10^5$	$3{,}3 \cdot 10^5$	$4{,}0 \cdot 10^5$	$4{,}1 \cdot 10^3$	$1{,}2 \cdot 10^6$	$3{,}3 \cdot 10^6$	$4{,}0 \cdot 10^6$	$4{,}1 \cdot 10^4$
goat (meat)	$1{,}2 \cdot 10^5$	$3{,}3 \cdot 10^5$	$4{,}0 \cdot 10^5$	$4{,}1 \cdot 10^3$	$1{,}2 \cdot 10^6$	$3{,}3 \cdot 10^6$	$4{,}0 \cdot 10^6$	$4{,}1 \cdot 10^4$
lamb	$1{,}9 \cdot 10^5$	$1{,}5 \cdot 10^5$	n. *	$1{,}5 \cdot 10^3$	$1{,}9 \cdot 10^6$	$1{,}5 \cdot 10^6$	n. *	$1{,}5 \cdot 10^4$
chicken (meat)	$1{,}8 \cdot 10^5$	$1{,}7 \cdot 10^6$	$3{,}3 \cdot 10^6$	$2{,}2 \cdot 10^3$	$1{,}8 \cdot 10^6$	$1{,}7 \cdot 10^7$	$3{,}3 \cdot 10^7$	$2{,}2 \cdot 10^4$
chicken (egg)	$2{,}1 \cdot 10^4$	$5{,}9 \cdot 10^3$	$7{,}3 \cdot 10^4$	$5{,}1 \cdot 10^4$	$2{,}1 \cdot 10^5$	$5{,}9 \cdot 10^4$	$7{,}3 \cdot 10^5$	$5{,}1 \cdot 10^5$

* Transfer factors are lacking and thus no values were given.

When evaluating the limit values, the SSK established that

- the chemo-toxic effect of Am and Pu on productive livestock might exclude long-term feeding (must be examined by toxicologists),
- with equal specific contamination of feedstuffs the contamination of meat from turkeys and geese may be lower than that of the chicken meat quoted here,
- breeding sows were not examined since no data on transfer parameters were available although they constitute 5 to 6% of the entire production of porc,
- the transfer factor feedstuffs-meat may be lower for beef cows than those values quoted in Tables 2 to 5 for fattening cattle,
- the calculations made for shortlived I 131 should not be accepted for longer-lived iodine isotopes without further examination,
- when applied optimally, the measures listed in Table 7 allow the use of higher contaminated fodder which will not lead to a situation where the limit values for radioactivity in foodstuffs of animal origin are exceeded.

As one example of the use of measures to reduce the contamination of foodstuffs of animal origin by changing feeding procedures and production, we should like to explain the effect of the use of higher contaminated fodder at different points in time during the fattening period and for different types of productive livestock on the contamination of foodstuffs of animal origin.

Table 9 shows up to which point in time during the fattening period fodder may be used with activity concentrations which fall under “restricted use” in Table 8. If uncontaminated fodder is used after this point in time, fodder that is contaminated with Cs 137 may be used during the first quarter of the fattening period for chicken, whereas it may be used during the first two thirds of the fattening period for cattle. If fodder is contaminated with Sr 90 the animal may be slaughtered 10 days after the feeding of highly contaminated fodder has been stopped.

Finally, it must be mentioned that if fodder is contaminated with Cs 137 those periods of time given in Table 9 in which highly contaminated fodder may be used can be prolonged considerably by adding alkali-iron-hexacyanoferrates or bentonite.

Table 9: Period of time during fattening period in which feedstuffs with the contamination listed in Table 8 under “use under certain conditions” may be used

animal	fattening period	period of time when highly contaminated food may be used	
		Cs 137	Sr 90
fattening pig	150 d	0 - 50 d	0 - 140 d
fattening cattle	500 d	0 - 330 d	0 - 490 d
fattening chicken	50 d	0 - 12 d	0 - 40 d
fattening lamb	150 d	0 - 85 d	0 - 140 d
fattening calf	100 d	0 - 40 d	0 - 90 d

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