Recent International Developments on Contamination Limits on Packages

J.Hesse, RWE Power, Germany; B.Lorenz, GNS, Germany

1. Introduction

In 1998 several events had been reported in the German media on non-compliance with the contamination limits for transport of spent fuel to and from the reprocessing facilities in France and the UK. The reporting developed to a tremendous media campaign and led to a transport stop announced by the authorities in several European countries. E.g. in Germany the transport of spent fuel from power reactors was interrupted for about 3 years.

In the meantime a lot of efforts were taken by the industry and the authorities to overcome the situation and to agree on a new concept of contamination prevention and control. Today it can be stated, that these measures have proven to be effective and no non-compliance with the contamination limits have been observed for spent fuel transports.

It soon became evident that none of the reported contamination findings led to any remarkable dose to members of the public or to any radiation worker involved in the transports. So from the very beginning of that discussion many parties involved in the affair were convinced that the existing system of contamination limits in the transport regulations was no longer up-to-date and needed modernisation.

A number of proposals were made by different countries and on behalf of the nuclear industry by the WNTI World Nuclear Transport Institute. Finally, the IAEA launched a Co-ordinated Research Project (CRP) on the Radiological Aspects of Package and Conveyance Non-Fixed Contamination to deal with all items of concern.

One of the major tasks of the CRP, which lasted from 2001 till 2003, was to develop a new model for contamination limits for the transport of radioactive material and associated equipment. WNTI was one of the 7 participating parties, including also France, Germany, Japan, Sweden, UK and USA. The WNTI working group was formed basically by the German organisation VGB, which comprises all German nuclear power plants.

This WNTI working group has created a model on its own as input to the CRP. In several special meetings with the other groups it was developed to an international radiological model, and was then adopted by the whole CRP group.

In the following we will describe the radiological model proposed to calculate doses from non-fixed (removable) surface contamination during transport of radioactive material and the results of the model calculations. Taking into account these results and also the efforts necessary for decontamination and contamination control we finally will discuss, wether the actual contamination limits are still appropriate.

2. Fairbairne Model

The starting point of the considerations was the analysis of the Fairbairn model, which up to now has served as the basis for the current surface contamination values for transport. The results of this old model, described in a paper of 1961, have since then been in use (having undergone the only change in the transition from Curie to Becquerel as the new unit for radioactivity, rounding up from 3.7 to 4).

The Fairbairn model is based on a single exposure situation involving

- “most hazardous radioisotopes in common use”: Pu 239, Ra 226, Sr 90.
- “very dusty operations” with a resuspension factor of $4 \cdot 10^{-5}$ m^{-1}
- 2000 hours per year working in that “dusty” atmosphere
- taking into account skin contamination and inhalation only
- 50 mSv/a as basis for deriving the contamination limits
- no considerations of the doses of members of the public

This approach does not take into account the very large differences in the radiological properties of radionuclides and is not appropriate for the real transport situations nowadays. So the Fairbairn model can be judged as very conservative. On the flipside it derives the contamination limits from the basic individual dose limit of workers, what probably would no longer be accepted nowadays.

3. New Model

After an analysis of the Fairbairne model the WNTI/VGB group decided to built up a new model taking into account

- radionuclid specific data of all radionuclides
- different kinds of packages
- the single steps during a transport (time of steps, distance between worker and package etc.)
- differentiation between indoor and outdoor operations
- all possible exposure pathways
- the exposure of workers and members of the public as well

3.1 Types of packages

As a reasonable compromise between all existing packages and the objective of the model to be representative for any type of packages, we chose four different package types as representatives: Small manually handled packages, small remotely handled packages (200l drum), large remotely handled packages (20' container), and fuel flasks. An overview is given in the following table

Table 1: Overview of package types

Package / container type	Dimensions	total volume	total surface area
SM: small manual (parcel)	0.3 x 0.3 x 0.3 m³	0.03 m³	0.5 m²
SR: small remote (200 l drum)	height 0.9 m, diameter 0.6 m	0.25 m³	2.3 m²
LR: large remote (20' container)	5.9 x 2.4 x 2.4 m³	34 m³	68 m²
FF: fuel flask (with fins)	length 6 m, diameter 2.5 m	29 m³	130 m² (incl. fins)

3.2 Steps during transport

The basic modelling principle was the assumption that any transport can be defined as a sequence of steps and several actions (sub-steps) during these steps. Table 2 gives an overview of the main steps, the actions they consists of and the groups of persons who might be possibly exposed.

The transport process which is modelled here covers the period from the final inspection of the package before detachment up to the receiving inspection and transfer to the final destination place. The starting point of the model is within a nuclear facility. It was thought to be adequate to start at that moment, when a package is decided to become a package for transport. There might be several processes in a nuclear facility, where radioactive material is handled and will remain within the facility. All these processes are under the supervision of the radiation protection regime for the facility, basically governed by the principles of the IAEA Basic Safety Standards and the corresponding national regulations, probably ruled by a license. It is therefore not necessary to cover these actions by the transport model. Thus the model does not cover any preparatory steps like e.g. decontamination of the package or container to the contamination limits

The endpoint of the model. is the receiving inspection and the end control of the transport equipment, especially the vehicle. It does not cover the opening of the package and removal of the radioactive contents as this will be the beginning of a new action within the framework of the site/facility license.

Table 2 Steps relevant for the transport model, persons involved

Main Step	Action	Persons involved	Workers			
			SM	SR	LR	FF
1. Final Inspection of Package	1.1 Visual inspection	Personnel	A	A	A	A
	1.2 Dose rate meas.		A	A	A	A
	1.3 Contamination measurement (final meas.)		A	A	A	A
	1.4 Labelling of package		A	A	A	A
2. Loading onto convey-ance	2.1 Transfer from site to conveyance	Personnel	C	BC	BC	B
	2.2 Fastening, loading, lifting and fixing		C	BC	BC	B
	2.3 Dose rate meas. at conveyance		AC	AC	A	A
	2.4 Contamination meas. of conveyance		AC	AC	A	A
	2.5 Placarding of conveyance		AC	AC	A	A
3. Movement phase	3.1 Movement (with packages)	Personnel	C	C	C	C
	3.2 Unforeseen interruptions		C	C	C	C
	3.1a Movement, public, road/rail	Public	no	no	no	no
	3.1b Movement, public, air		no	no	no	no
	3.1c Movement, public, sea		no	no	no	no
	3.3 Regular stops		no	no	no	no
4. Transfers during trans-port	4.1 Unloading (incl. sub-steps) from conv. #1					
	4.1.1 dose rate & contam. meas.	Personnel, Public	no	F	H	H
	4.1.2 unfixing, fastening, lifting		F	F	FG	FG
	4.2 Loading (incl. sub-steps) on conv. #2					
	4.2.1 transfer, loading, fixing		F	F	FG	FG
	4.2.2 dose rate meas. at conveyance		F	F	H	H
	4.2.3 contamination meas. of coveyance		F	F	H	H
	4.2.4 placarding of conveyance		F	F	F	F
	4.3 Regular stops	Public	no	no	no	no
5. Receiving inspection and unloading	5.1 Visual inspection of load	Personnel	T	T	T	T
	5.2 Dose rate meas. conveyance		no	no	no	T
	5.3 Unfixing, fastening, lifting, unloading		C	CU	CU	U
	5.4 Transfer from conveyance to consignee		C	CU	CU	U
	5.5 Dose rate measurement package		T	T	T	T
	5.6 Contamination meas. package		no	T	T	T
	5.7 Contamination meas. empty conveyance		no	no	T	T

3.3 Workers assigned to the actions

The model also takes into account that the different steps of a transport are done by different workers. That is shown in table 2, too, as follows:

Workers A and B are involved in the package preparation and the transfer to the conveyance. In the case of small manually handled packages it is assumed that there is no special transfer worker B. Worker C is the driver. Workers F, G, H are working at the transfer site, T and U at the consignee's premises. Multiple letters per box indicate that the step may be carried out by either of the persons.

That gives a general idea of what each worker group is meant to consist of. There might be deviations from the actual working conditions, but the model is still realistic and also sufficiently conservative, which requires slight overestimation rather than underestimation of working time and tasks per person.

3.4 Annual exposure time

For all steps the annual time of exposure was modelled by multiplying the time of the single step by the number of such steps a person might do per year as shown in the following table.

Table 3: Parameters concerning shipments and annual working time

Parameter	unit	Parameter value for: SM		SR	LR	FF
number of days per year	d/a	250		250	250	250
working hours per day	h/d	8		8	8	8
annual working time	h/a	2000		2000	2000	2000
cut-off annual working time	[-]	75%		75%	75%	75%
number of loads handled per day	1/d	2*	1*	1	1	0.5
packages per conveyance	[-]	25*	100*	42 (25)**	1	1
packages per year	1/a	25,000		6,250	250	125
geometry of packages on conveyance		2 layers of 15/10 packages		2 layers of 3x7 drums	1 container	1 fuel flask

*) either 1 load of 100 packages or 2 loads of 25 packages per day – differences in the type of conveyance are assumed
**) It is assumed that a load consists of 42 packages of which 25 are handled by a single worker

The next table shows as an example the assumed time and some other parameter details for the step “visual inspection”.

Table 4 Parameters for the substep “visual inspection”

1.1 Visual inspection			SM	SR	LR	FF
exposure time per package	$t_{exp,s}$	min	0,5	1	5	10
exposure time per year	$t_{exp,total}$	h/a	208	175	21	21
persons involved			A	A	A	A
distance to package	l_{extirr}	m	1	1	1	1
number of packages			1	1	1	1
exposure geometry			24	14	20	20
resuspension rate	f_{resus}	1/h	1,00E-04	1,00E-04	1,00E-04	1,00E-04
act. conc. air (room) 1 Bq/cm², 1 package	$A_{air,room}$	Bq/m³	1,08E-03	4,52E-03	1,70E-02	3,25E-02

3.5 Exposure Pathways

The following exposure pathways pertaining to non-fixed surface contamination on packages are included in the model:

- external irradiation from the removable surface contamination (not by the contents of the package);
- inhalation of radioactive aerosols re-suspended from the contaminated surface;
- ingestion of radioactivity via a hand-to-mouth pathway, i.e. the hand touches the radioactively contaminated surface and subsequently gets into contact with the mouth;
- skin contamination resulting from direct skin contact with the contaminated surface.

In addition, there are other pathways which, however, may give rise only to insignificant dose contributions. They have been considered for a number of scenarios especially in connection with a potential dose to members of the public but have been disregarded for further inclusion in the model. Examples of such insignificant pathways are:

- ingestion of foodstuff grown in the vicinity of a transport path
- external radiation or other dose paths from fall-out or wash-out of radioactivity from contaminated packages
- secondary resuspended activity from deposited surface contamination

- contamination build-up by frequent and continued use of places/ways for transport or temporary storage of packages
- secondary contamination of passenger areas through ventilation connections with freight areas containing packages with radioactive materials.

For the sake of time we cannot show all the parameters of the model here. Parameters had to be chosen also for all the different exposure pathways, e.g. for the volume of a room with packages, for the detailed geometry to calculate the exposure by direct radiation in all different cases, the dose coefficients, etc.
All parameters were discussed several times. However, in the CRP consensus between all groups could be found concernig all parameters of the model.

3.6 Calculations and results

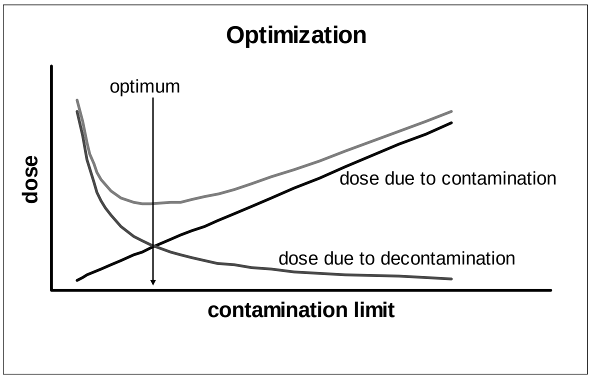
Calculation were made nuclide specifically by assuming a contamination of 1 Bq/cm² on the entire surface of every package. Results were calculated in Sv/(Bq/cm²) for every single step and every single involved person. For an easier comparison with the existing contamination limit we calculated in a second step the contamination leading to a dose of 2 mSv/a for the most exposed worker and the contamination leading to a dose of 0.3 mSv/a for a member of the public. A part of the results are shown in table 5. The complete table of all radionuclides can be seen in the annex.

Table 5 Final results (part of the complete table) for surface contamination levels in Bq/cm², which correspond to a dose constraint of 2 mSv/a for workers and of 0.3 mSv/a for members of the public

	Derived Level Workers [Bq/cm²]				Derived Level Public [Bq/cm²]				
Nuclide	W-SM	W-SR	W-LR	W-FF	P-SM	P-SR	P-LR	P-FF	**Overall Min.**
Cm-248	0,1	1,6	2,1	1,7	31	6	68	46	0,1
Co-55	135	134	305	407	1,8E+5	1,9E+4	4,0E+3	7,6E+3	134
Co-56	81	80	185	249	9,7E+4	1,1E+4	2,3E+3	4,5E+3	80
Co-57	2,3E+3	2,2E+3	4,9E+3	6,4E+3	2,3E+6	2,8E+5	6,8E+4	1,3E+5	2,2E+3
Co-58	270	268	621	834	3,2E+5	3,6E+4	7,9E+3	1,5E+4	268
Co-58m	1,2E+5	1,3E+5	1,3E+5	1,3E+5	3,5E+8	7,1E+7	3,1E+8	3,5E+8	1,2E+5
Co-60	109	108	245	323	1,1E+5	1,3E+4	3,2E+3	6,1E+3	108
Cr-51	8,2E+3	8,2E+3	1,8E+4	2,4E+4	1,0E+7	1,1E+6	2,4E+5	4,7E+5	8,2E+3
Cs-129	893	886	2,1E+3	2,8E+3	1,2E+6	1,2E+5	2,6E+4	4,9E+4	886
Cs-131	7,7E+3	7,7E+3	1,7E+4	2,2E+4	1,0E+7	1,1E+6	2,4E+5	4,6E+5	7,7E+3
Cs-132	362	359	836	1,1E+3	4,7E+5	5,0E+4	1,0E+4	2,0E+4	359
Cs-134	129	128	227	266	1,7E+5	2,0E+4	4,9E+3	9,3E+3	128
Cs-134m	6,4E+3	6,4E+3	1,1E+4	1,2E+4	1,2E+7	1,2E+6	2,6E+5	5,0E+5	6,4E+3
Cs-135	4,0E+3	4,6E+3	4,6E+3	4,6E+3	6,7E+6	1,4E+6	1,5E+7	1,0E+7	4,0E+3
Cs-136	122	121	274	363	1,6E+5	1,7E+4	3,6E+3	6,9E+3	121
Cs-137	284	283	439	487	3,8E+5	5,0E+4	1,3E+4	2,5E+4	283
Cu-64	1,3E+3	1,3E+3	2,8E+3	3,6E+3	1,8E+6	1,9E+5	4,0E+4	7,6E+4	1,3E+3

4. Discussion and conclusions

The model calculations have been internationally harmonized within the IAEA CRP for all necessary parameters. The CRP failed however to agree finally about the mode of deriving a contamination limit or level. The discussion on this subject was rather divers and no consensus could be achieved.



However, it is essential for radio protection to find and establish an adequate level of contamination. It has to be taken into account that too low contamination limits can have an effect converse to the wished effect of protection.
The lower the contamination limits are the higher efforts of decontamination and measurements are needed to ensure compliance with the limits. This work has to be done in the radiation field produced by the contents of the packages. So it results in a higher dose of the workers. This situation is shown in Fig. 1. The dose

due to the contamination competes with the dose due to decontamination. If the legal contamination limit is higher than the optimum, it is possible to reach the optimum by putting a lower “internal” limit. However, if the legal contamination limit is lower than this optimum, it is impossible to reach the optimum. This is the situation we have to get along with today

The following tables show for the two radionuclides Co-60 and Cs-137, which most times dominate the contamination from a NPP , the doses corresponding with the actual contamination limit of 4 Bq/cm².

Table 6 Annual effective dose of the most exposed workers due to a contamination of 4 Bq/cm²

	Small manual	Small remote	Large remote	Fuel Flask
Co-60	73 µSv/a	74 µSv/a	33 µSv/a	25 µSv/a
Cs-137	28 µSv/a	28 µSv/a	18 µSv/a	16 µSv/a

Table 7 Annual effective dose of a member of the public due to a contamination of 4 Bq/cm²

	Small manual	Small remote	Large remote	Fuel flask
Co-60	0,011 µSv/a	0,092 µSv/a	0,375 µSv/a	0,197. µSv/a
Cs-137	0,003 µSv/a	0,024 µSv/a	0,092 µSv/a	0,048 µSv/a

These doses are calculated still with the very conservative assumption that the complete surface of every package is contaminated up to the actual contamination limit of 4 Bq/cm², which means a factor of conservaty in the order of 10 or even 100. In the case of fuel flaskes these values are based on the assumption that one worker handles 125 flasks per year. So the dose per flask is only 0,2 µSv/flask (Co-60), respectively 0,1 µSv/flask (Cs-137). These calculated potential doses should be compared with the real doses workers get to reach sure compliance with the contamination limits. Referring to a paper of J.P Degrange et. al from the last European ISOE workshop in 2002, the operations of prevention, elimination and monitoring of the surface contamination of the irradiated fuel casks before shipment contribute significantly with about 42% to the collective dose of the involved workers. In total they estimated as sum for all French NPPs a dose of 1,3 manSv per year for these steps before the actual shipment. From German NPPs we know that some workers get doses in the order of 1mSv due to the decontamination and monitoring of one single cask.

Additionally the calculations show that the dose per unity surface activity (Sv/a per Bq/cm²) strongly depends on the radionuclide. The calculated values reach over about seven orders of magnitude. This is due to the fact that the different radiological importance of the different radionuclides directly influences the calculation. Today only one order of magnitude is reflecting the differences between radionuclides. The actual limitation by only two values (0.4 Bq/cm² for alpha emitters and 4 Bq/cm² for the other nuclides) does not approximately reflect the radiological importance of the different radionuclides adequately.

When setting contamination limits there are of course also other aspects to be taken into account as:

- A reached level of cleanliness should not be given up without reason.
- The dose due to contamination should be only a part of the dose for the whole process.
- The contamination limits for transports should be in compliance with the contamination limits in the receiving facilities
- New contamination limits must be justifiable also in a political debate with the public

Even taking into account these additional conditions it seems to be appropriate to put the contamination limits on the basis of the described new international model of the IAEA CRP. It is much more realistic than the Fairbairne model of 1961 and still rather conservative. This would mean to substitute the actual limits by radionuclidspecific ones and to consider an appropriate constraint, e.g. 2 mSv/a for workers, for the derivation of these limits.

Annex

Final results for surface contamination levels in Bq/cm² which correspond to a dose constraint of 2 mSv/a for workers and of 0.3 mSv/a for members of the public

Nuclide	Derived Level Workers [Bq/cm²]				Derived Level Public [Bq/cm²]				Overall Min.
	W-SM	W-SR	W-LR	W-FF	P-SM	P-SR	P-LR	P-FF	
Ac-225	21	158	190	171	5,1E+3	1,0E+3	8,9E+3	7,0E+3	21
Ac-227	0,036	0,4	0,6	0,5	8	1,7	18	12	0,036
Ac-228	204	223	400	454	1,3E+5	2,0E+4	8,4E+3	1,6E+4	204
Ag-105	405	402	750	901	6,0E+5	6,6E+4	1,4E+4	2,8E+4	402
Ag-108m	149	155	354	447	7,9E+4	1,2E+4	4,6E+3	8,5E+3	149
Ag-110m	97	97	223	296	9,8E+4	1,2E+4	2,9E+3	5,4E+3	97
Ag-111	2,4E+3	2,8E+3	3,4E+3	3,4E+3	2,3E+6	4,0E+5	2,8E+5	4,9E+5	2,4E+3
Al-26	102	102	225	290	8,9E+4	1,1E+4	3,1E+3	5,9E+3	102
Am-241	0,5	6	8	6	111	23	244	165	0,5
Am-242m	0,6	6	8	7	126	26	277	187	0,6
Am-243	0,5	6	8	6	113	23	249	169	0,5
As-72	143	142	312	408	1,9E+5	2,1E+4	4,3E+3	8,3E+3	142
As-73	8,8E+3	1,3E+4	1,6E+4	1,7E+4	4,3E+6	8,2E+5	1,1E+6	1,8E+6	8,8E+3
As-74	320	318	691	891	3,8E+5	4,3E+4	9,8E+3	1,9E+4	318
As-76	490	488	887	1,1E+3	7,3E+5	8,2E+4	1,8E+4	3,5E+4	488
As-77	5,7E+3	6,1E+3	6,9E+3	7,0E+3	9,3E+6	1,6E+6	8,7E+5	1,6E+6	5,7E+3
At-211	162	611	661	636	4,2E+4	8,5E+3	6,3E+4	5,4E+4	162
Au-193	1,7E+3	1,7E+3	3,4E+3	4,4E+3	2,3E+6	2,5E+5	5,3E+4	1,0E+5	1,7E+3
Au-194	264	261	613	832	3,4E+5	3,7E+4	7,6E+3	1,5E+4	261
Au-195	2,9E+3	2,9E+3	5,9E+3	7,2E+3	2,2E+6	3,0E+5	9,5E+4	1,8E+5	2,9E+3
Au-198	477	474	820	954	7,5E+5	8,5E+4	1,9E+4	3,6E+4	474
Au-198m	232	231	445	542	3,1E+5	3,5E+4	8,0E+3	1,5E+4	231
Au-199	2,4E+3	2,4E+3	4,3E+3	5,0E+3	2,6E+6	3,4E+5	9,2E+4	1,7E+5	2,4E+3
Ba-131	506	502	1,2E+3	1,5E+3	6,6E+5	7,1E+4	1,5E+4	2,8E+4	502
Ba-133	611	607	1,3E+3	1,7E+3	6,8E+5	8,0E+4	1,9E+4	3,6E+4	607
Ba-133m	1,7E+3	1,7E+3	2,3E+3	2,5E+3	4,1E+6	4,6E+5	1,0E+5	2,0E+5	1,7E+3
Ba-140	109	108	240	314	1,4E+5	1,5E+4	3,3E+3	6,3E+3	108
Be-7	5,2E+3	5,2E+3	1,2E+4	1,7E+4	6,5E+6	7,1E+5	1,5E+5	2,9E+5	5,2E+3
Be-10	1,21E+3	2,4E+3	2,5E+3	2,5E+3	4,8E+5	9,9E+4	1,1E+6	7,2E+5	1,21E+3
Bi-205	175	173	406	550	2,2E+5	2,4E+4	5,0E+3	9,7E+3	173
Bi-206	83,4	83	193	260	1,1E+5	1,1E+4	2,4E+3	4,6E+3	82,7
Bi-207	174,0	173	397	527	1,8E+5	2,2E+4	5,1E+3	9,7E+3	172,9
Bi-210	224,27	1,6E+3	1,9E+3	1,7E+3	5,0E+4	1,0E+4	1,1E+5	7,5E+4	224,27
Bi-210m	6,39E+00	6,99E+01	9,30E+01	7,76E+01	1,4E+3	278	2,7E+3	2,0E+3	6,39E+00
Bi-212	194,0	210	477	594	9,9E+4	1,5E+4	6,3E+3	1,2E+4	194
Bk-247	0,3	3,4	5	3,7	67	14	148	100	0,3
Bk-249	132	1,4E+3	1,9E+3	1,6E+3	2,9E+4	5,9E+3	6,4E+4	4,3E+4	132
Br-76	110	109	248	330	1,5E+5	1,6E+4	3,2E+3	6,2E+3	109
Br-77	844	836	2,0E+3	2,7E+3	1,1E+6	1,2E+5	2,4E+4	4,7E+4	836
Br-82	103	102	240	327	1,3E+5	1,4E+4	3,0E+3	5,7E+3	102
C-11	260,2	258	618	852	3,4E+5	3,6E+4	7,4E+3	1,4E+4	258,0
C-14	1,01E+4	1,4E+4	1,4E+4	1,4E+4	2,3E+6	4,7E+5	5,1E+6	3,5E+6	1,01E+4
Ca-41	2,63E+4	3,3E+4	3,3E+4	3,3E+4	4,9E+7	1,0E+7	1,1E+8	7,3E+7	2,63E+4
Ca-45	4,3E+3	9,2E+3	9,5E+3	9,3E+3	1,7E+6	3,5E+5	3,8E+6	2,6E+6	4,3E+3
Ca-47	227,0	225	488	629	2,7E+5	3,1E+4	7,0E+3	1,3E+4	225,4
Cd-109	1,16E+3	1,7E+3	1,9E+3	2,0E+3	6,6E+5	1,3E+5	1,9E+5	3,0E+5	1,16E+3
Cd-113m	198	362	369	365	8,9E+4	1,8E+4	2,0E+5	1,3E+5	198
Cd-115	603	599	1,2E+3	1,4E+3	7,7E+5	8,9E+4	2,0E+4	3,9E+4	599
Cd-115m	1,1E+3	1,6E+3	1,8E+3	1,8E+3	7,2E+5	1,4E+5	3,0E+5	4,3E+5	1,1E+3
Ce-139	1,5E+3	1,5E+3	3,4E+3	4,3E+3	1,2E+6	1,6E+5	4,7E+4	8,9E+4	1,5E+3
Ce-141	2,0E+3	2,4E+3	4,0E+3	4,4E+3	1,1E+6	1,9E+5	1,0E+5	1,8E+5	2,0E+3
Ce-143	767	763	1,4E+3	1,7E+3	1,0E+6	1,2E+5	2,7E+4	5,2E+4	763
Ce-144	382	965	1,1E+3	1,0E+3	1,3E+5	2,5E+4	1,0E+5	1,2E+5	382
Cf-248	2,4	28	38	31	529	107	1,2E+3	788	2,4
Cf-249	0,3	3,4	4	3,7	66	14	146	99	0,3
Cf-250	0,6	7	9	8	137	28	302	204	0,6
Cf-251	0,3	3,3	4	3,6	66	13	144	98	0,3
Cf-252	1,1	12	17	14	233	47	513	347	1,1
Cf-253	17	202	278	225	3,6E+3	728	7,9E+3	5,3E+3	17
Cf-254	0,5	5	7	6	113	23	250	169	0,5

Nuclide	Derived Level Workers [Bq/cm²]				Derived Level Public [Bq/cm²]				Overall Min.
	W-SM	W-SR	W-LR	W-FF	P-SM	P-SR	P-LR	P-FF	
Cl-36	1,8E+3	4,5E+3	4,6E+3	4,5E+3	6,4E+5	1,3E+5	1,4E+6	9,5E+5	1,8E+3
Cl-38	194	193	412	531	2,8E+5	2,9E+4	6,0E+3	1,2E+4	193
Cm-240	7	81	110	90	1,5E+3	296	3,2E+3	2,2E+3	7
Cm-241	303	474	1,0E+3	1,1E+3	1,1E+5	1,9E+4	1,5E+4	2,6E+4	303
Cm-242	4	49	67	55	895	182	2,0E+3	1,3E+3	4
Cm-243	0,7	8	10	8	150	31	329	223	0,7
Cm-244	0,8	9	12	10	172	35	380	257	0,8
Cm-245	0,5	6	7	6	111	23	244	165	0,5
Cm-246	0,5	6	7	6	111	23	244	165	0,5
Cm-247	0,6	6	8	7	119	24	260	177	0,6
Cm-248	0,1	1,6	2,1	1,7	31	6	68	46	0,1
Co-55	135	134	305	407	1,8E+5	1,9E+4	4,0E+3	7,6E+3	134
Co-56	81	80	185	249	9,7E+4	1,1E+4	2,3E+3	4,5E+3	80
Co-57	2,3E+3	2,2E+3	4,9E+3	6,4E+3	2,3E+6	2,8E+5	6,8E+4	1,3E+5	2,2E+3
Co-58	270	268	621	834	3,2E+5	3,6E+4	7,9E+3	1,5E+4	268
Co-58m	1,2E+5	1,3E+5	1,3E+5	1,3E+5	3,5E+8	7,1E+7	3,1E+8	3,5E+8	1,2E+5
Co-60	109	108	245	323	1,1E+5	1,3E+4	3,2E+3	6,1E+3	108
Cr-51	8,2E+3	8,2E+3	1,8E+4	2,4E+4	1,0E+7	1,1E+6	2,4E+5	4,7E+5	8,2E+3
Cs-129	893	886	2,1E+3	2,8E+3	1,2E+6	1,2E+5	2,6E+4	4,9E+4	886
Cs-131	7,7E+3	7,7E+3	1,7E+4	2,2E+4	1,0E+7	1,1E+6	2,4E+5	4,6E+5	7,7E+3
Cs-132	362	359	836	1,1E+3	4,7E+5	5,0E+4	1,0E+4	2,0E+4	359
Cs-134	129	128	227	266	1,7E+5	2,0E+4	4,9E+3	9,3E+3	128
Cs-134m	6,4E+3	6,4E+3	1,1E+4	1,2E+4	1,2E+7	1,2E+6	2,6E+5	5,0E+5	6,4E+3
Cs-135	4,0E+3	4,6E+3	4,6E+3	4,6E+3	6,7E+6	1,4E+6	1,5E+7	1,0E+7	4,0E+3
Cs-136	122	121	274	363	1,6E+5	1,7E+4	3,6E+3	6,9E+3	121
Cs-137	284	283	439	487	3,8E+5	5,0E+4	1,3E+4	2,5E+4	283
Cu-64	1,3E+3	1,3E+3	2,8E+3	3,6E+3	1,8E+6	1,9E+5	4,0E+4	7,6E+4	1,3E+3
Cu-67	1,5E+3	1,5E+3	2,4E+3	2,7E+3	2,3E+6	2,9E+5	7,0E+4	1,3E+5	1,5E+3
Dy-159	4,8E+3	4,8E+3	1,1E+4	1,4E+4	4,3E+6	5,5E+5	1,4E+5	2,7E+5	4,8E+3
Dy-165	3,9E+3	3,9E+3	5,0E+3	5,2E+3	1,1E+7	1,3E+6	2,9E+5	5,6E+5	3,9E+3
Dy-166	1,5E+3	1,6E+3	2,1E+3	2,2E+3	1,3E+6	2,2E+5	1,1E+5	1,9E+5	1,5E+3
Er-169	8,7E+3	1,4E+4	1,4E+4	1,4E+4	4,7E+6	9,5E+5	1,0E+7	6,9E+6	8,7E+3
Er-171	647	642	1,3E+3	1,7E+3	9,1E+5	9,9E+4	2,1E+4	4,0E+4	642
Eu-147	322	320	745	1,0E+3	3,9E+5	4,3E+4	9,3E+3	1,8E+4	320
Eu-148	124	123	289	392	1,5E+5	1,7E+4	3,6E+3	6,9E+3	123
Eu-149	3,2E+3	3,2E+3	7,2E+3	9,5E+3	3,4E+6	4,0E+5	9,4E+4	1,8E+5	3,2E+3
Eu-150	331	1,5E+3	1,7E+3	1,6E+3	8,7E+4	1,7E+4	8,9E+4	9,2E+4	331
Eu-152	188	226	517	629	8,2E+4	1,3E+4	6,7E+3	1,2E+4	188
Eu-152m	741	736	1,5E+3	1,8E+3	1,1E+6	1,2E+5	2,5E+4	4,7E+4	736
Eu-154	160	204	456	542	6,7E+4	1,1E+4	6,1E+3	1,1E+4	160
Eu-155	1,9E+3	3,6E+3	7,0E+3	7,4E+3	6,1E+5	1,1E+5	1,2E+5	2,0E+5	1,9E+3
Eu-156	200	198	425	545	2,4E+5	2,7E+4	6,2E+3	1,2E+4	198
F-18	260	258	593	797	3,5E+5	3,7E+4	7,6E+3	1,5E+4	258
Fe-52	85	85	198	268	1,1E+5	1,2E+4	2,5E+3	4,7E+3	85
Fe-55	1,9E+4	2,7E+4	2,7E+4	2,7E+4	1,2E+7	2,5E+6	2,7E+7	1,8E+7	1,9E+4
Fe-59	228	227	509	668	2,5E+5	2,9E+4	6,8E+3	1,3E+4	227
Fe-60	57	87	88	87	3,3E+4	6,8E+3	7,3E+4	5,0E+4	57
Ga-67	1,7E+3	1,7E+3	3,5E+3	4,4E+3	2,2E+6	2,5E+5	5,5E+4	1,0E+5	1,7E+3
Ga-68	260	258	564	734	3,6E+5	3,9E+4	7,9E+3	1,5E+4	258
Ga-72	107	106	243	326	1,4E+5	1,5E+4	3,1E+3	6,0E+3	106
Gd-146	97	96	220	292	1,1E+5	1,3E+4	2,9E+3	5,5E+3	96
Gd-148	1,8	20	27	22	423	86	933	631	1,8
Gd-153	2,1E+3	2,1E+3	4,6E+3	5,7E+3	1,3E+6	1,8E+5	6,3E+4	1,2E+5	2,1E+3
Gd-159	3,2E+3	3,2E+3	4,4E+3	4,8E+3	5,7E+6	7,1E+5	1,8E+5	3,5E+5	3,2E+3
Ge-68	266	265	608	784	1,7E+5	2,5E+4	7,9E+3	1,5E+4	265
Ge-71	5,8E+5	7,8E+5	7,9E+5	7,9E+5	4,2E+8	8,6E+7	9,3E+8	6,3E+8	5,8E+5
Ge-77	235	233	496	637	3,2E+5	3,5E+4	7,3E+3	1,4E+4	233
Hf-172	699	1,6E+3	2,8E+3	2,9E+3	2,2E+5	4,1E+4	5,7E+4	9,1E+4	699
Hf-175	690	686	1,5E+3	2,0E+3	7,6E+5	8,9E+4	2,1E+4	3,9E+4	686
Hf-181	447	445	952	1,2E+3	3,8E+5	5,0E+4	1,4E+4	2,6E+4	445

Nuclide	Derived Level Workers [Bq/cm²]				Derived Level Public [Bq/cm²]				Overall Min.
	W-SM	W-SR	W-LR	W-FF	P-SM	P-SR	P-LR	P-FF	
Hf-182	142	651	939	911	3,5E+4	7,0E+3	2,3E+4	2,9E+4	142
Hg-194	112	112	149	158	2,1E+5	2,8E+4	7,5E+3	1,4E+4	112
Hg-195m	817	811	1,8E+3	2,3E+3	1,0E+6	1,1E+5	2,5E+4	4,8E+4	811
Hg-197	3,4E+3	3,4E+3	6,5E+3	7,9E+3	4,0E+6	4,9E+5	1,2E+5	2,3E+5	3,4E+3
Hg-197m	1,4E+3	1,4E+3	2,6E+3	3,1E+3	1,7E+6	2,1E+5	5,2E+4	1,0E+5	1,4E+3
Hg-203	943	941	1,8E+3	2,1E+3	8,7E+5	1,2E+5	3,4E+4	6,4E+4	941
Ho-166	2,2E+3	2,3E+3	2,6E+3	2,7E+3	4,6E+6	7,0E+5	2,7E+5	5,1E+5	2,2E+3
Ho-166m	96	153	350	393	3,3E+4	5,9E+3	4,6E+3	8,0E+3	96
I-123	1,5E+3	1,5E+3	3,3E+3	4,4E+3	2,0E+6	2,1E+5	4,4E+4	8,4E+4	1,5E+3
I-124	194	193	342	401	2,6E+5	3,1E+4	7,4E+3	1,4E+4	193
I-125	517	577	626	630	7,9E+5	1,4E+5	1,2E+5	2,1E+5	517
I-126	207	210	270	283	2,9E+5	4,3E+4	1,6E+4	3,0E+4	207
I-129	77	89	90	89	1,3E+5	2,6E+4	1,3E+5	1,3E+5	77
I-131	266	269	348	365	3,7E+5	5,5E+4	2,0E+4	3,7E+4	266
I-132	116	116	268	362	1,5E+5	1,6E+4	3,4E+3	6,5E+3	116
I-133	329	327	619	747	4,5E+5	5,2E+4	1,2E+4	2,2E+4	327
I-134	103	103	238	322	1,4E+5	1,5E+4	3,0E+3	5,7E+3	103
I-135	147	146	333	446	2,0E+5	2,1E+4	4,3E+3	8,3E+3	146
In-111	661	656	1,5E+3	2,0E+3	8,5E+5	9,2E+4	1,9E+4	3,7E+4	656
In-113m	953	945	2,1E+3	2,7E+3	1,3E+6	1,4E+5	2,9E+4	5,6E+4	945
In-114m	877	1,0E+3	1,5E+3	1,6E+3	5,9E+5	1,0E+5	5,6E+4	1,0E+5	877
In-115m	1,4E+3	1,4E+3	2,9E+3	3,7E+3	2,0E+6	2,2E+5	4,5E+4	8,7E+4	1,4E+3
Ir-189	2,9E+3	2,9E+3	5,7E+3	6,9E+3	3,0E+6	3,8E+5	9,8E+4	1,9E+5	2,9E+3
Ir-190	186	184	423	564	2,3E+5	2,5E+4	5,4E+3	1,0E+4	184
Ir-192	305	303	663	851	2,9E+5	3,6E+4	9,3E+3	1,8E+4	303
Ir-194	1,4E+3	1,4E+3	2,0E+3	2,2E+3	2,7E+6	3,4E+5	8,5E+4	1,6E+5	1,4E+3
K-40	761	761	999	1,1E+3	1,2E+6	1,7E+5	5,3E+4	1,0E+5	761
K-42	1,0E+3	1,0E+3	2,3E+3	3,0E+3	1,4E+6	1,5E+5	3,1E+4	5,9E+4	1,0E+3
K-43	266	264	600	800	3,6E+5	3,8E+4	7,8E+3	1,5E+4	264
La-137	3,7E+3	7,2E+3	1,6E+4	1,7E+4	1,2E+6	2,1E+5	2,1E+5	3,6E+5	3,7E+3
La-140	123	122	280	375	1,6E+5	1,7E+4	3,6E+3	6,9E+3	122
Lu-172	144	143	324	431	1,8E+5	2,0E+4	4,3E+3	8,2E+3	143
Lu-173	1,8E+3	1,8E+3	4,0E+3	5,0E+3	1,2E+6	1,7E+5	5,7E+4	1,1E+5	1,8E+3
Lu-174	1,6E+3	1,9E+3	3,8E+3	4,5E+3	8,0E+5	1,3E+5	6,1E+4	1,1E+5	1,6E+3
Lu-174m	2,3E+3	3,0E+3	5,4E+3	5,9E+3	1,0E+6	1,8E+5	1,2E+5	2,1E+5	2,3E+3
Lu-177	3,9E+3	4,2E+3	6,1E+3	6,5E+3	3,0E+6	4,8E+5	2,2E+5	4,1E+5	3,9E+3
Mg-28	90	90	203	269	1,2E+5	1,3E+4	2,7E+3	5,1E+3	90
Mn-52	80	79	185	251	1,0E+5	1,1E+4	2,3E+3	4,4E+3	79
Mn-53	1,8E+5	3,1E+5	3,2E+5	3,1E+5	8,6E+7	1,8E+7	1,9E+8	1,3E+8	1,8E+5
Mn-54	317	315	730	980	3,7E+5	4,2E+4	9,2E+3	1,8E+4	315
Mn-56	166	164	370	492	2,2E+5	2,4E+4	4,9E+3	9,4E+3	164
Mo-93	2,4E+3	3,2E+3	3,5E+3	3,5E+3	1,9E+6	3,6E+5	4,9E+5	7,9E+5	2,4E+3
Mo-99	846	841	1,6E+3	1,9E+3	1,1E+6	1,2E+5	2,9E+4	5,6E+4	841
N-13	260	258	619	853	3,4E+5	3,6E+4	7,4E+3	1,4E+4	258
Na-22	121	120	269	355	1,6E+5	1,7E+4	3,6E+3	6,9E+3	120
Na-24	78	77	180	245	1,0E+5	1,1E+4	2,2E+3	4,3E+3	77
Nb-93m	2,4E+4	4,5E+4	6,0E+4	6,1E+4	8,6E+6	1,7E+6	2,7E+6	4,1E+6	2,4E+4
Nb-94	165	164	374	490	1,5E+5	1,9E+4	4,9E+3	9,2E+3	164
Nb-95	344	341	791	1,1E+3	4,0E+5	4,5E+4	1,0E+4	1,9E+4	341
Nb-97	377	374	820	1,1E+3	5,2E+5	5,5E+4	1,1E+4	2,2E+4	374
Nd-147	1,3E+3	1,3E+3	2,3E+3	2,6E+3	1,2E+6	1,6E+5	5,2E+4	9,8E+4	1,3E+3
Nd-149	579	575	1,1E+3	1,4E+3	7,8E+5	8,8E+4	2,0E+4	3,7E+4	575
Ni-59	7,8E+4	1,5E+5	1,5E+5	1,5E+5	3,6E+7	7,3E+6	7,9E+7	5,3E+7	7,8E+4
Ni-63	2,7E+4	5,9E+4	6,1E+4	5,9E+4	9,7E+6	2,0E+6	2,1E+7	1,4E+7	2,7E+4
Ni-65	481	477	1,0E+3	1,3E+3	6,8E+5	7,3E+4	1,5E+4	2,9E+4	477
Np-235	3,3E+4	8,1E+4	1,1E+5	1,1E+5	1,1E+7	2,1E+6	4,0E+6	5,9E+6	3,3E+4
Np-236	7	71	93	78	1,5E+3	295	3,1E+3	2,1E+3	7
Np-237	0,9	11	14	12	202	41	440	300	0,9
Np-239	1,4E+3	1,4E+3	2,5E+3	3,0E+3	1,6E+6	1,9E+5	4,9E+4	9,3E+4	1,4E+3
Os-185	372	369	859	1,2E+3	4,4E+5	4,9E+4	1,1E+4	2,1E+4	369

Nuclide	Derived Level Workers [Bq/cm^2]				Derived Level Public [Bq/cm^2]				Overall Min.
	W-SM	W-SR	W-LR	W-FF	P-SM	P-SR	P-LR	P-FF	
Os-191	2,9E+3	3,0E+3	5,6E+3	6,4E+3	1,8E+6	2,8E+5	1,1E+5	2,0E+5	2,9E+3
Os-191m	1,8E+4	1,9E+4	2,3E+4	2,4E+4	2,3E+7	3,7E+6	1,6E+6	3,0E+6	1,8E+4
Os-193	2,2E+3	2,2E+3	3,2E+3	3,5E+3	3,4E+6	4,3E+5	1,1E+5	2,2E+5	2,2E+3
Os-194	605	1,3E+3	1,8E+3	1,8E+3	2,0E+5	4,0E+4	7,2E+4	1,1E+5	605
P-32	1,7E+3	2,2E+3	2,2E+3	2,2E+3	1,4E+6	2,8E+5	3,0E+6	2,0E+6	1,7E+3
P-33	8,7E+3	2,0E+4	2,0E+4	2,0E+4	3,1E+6	6,3E+5	6,8E+6	4,6E+6	8,7E+3
Pa-230	34	269	386	352	7,5E+3	1,5E+3	7,0E+3	7,6E+3	34
Pa-231	0,2	1,7	2,3	1,9	33	7	73	50	0,2
Pa-233	1,1E+3	1,1E+3	2,2E+3	2,6E+3	7,7E+5	1,1E+5	3,7E+4	6,9E+4	1,1E+3
Pb-201	309	307	717	971	4,1E+5	4,3E+4	8,9E+3	1,7E+4	307
Pb-202	705	1,1E+3	1,1E+3	1,1E+3	4,2E+5	8,6E+4	9,3E+5	6,3E+5	705
Pb-203	877	870	2,0E+3	2,6E+3	1,2E+6	1,2E+5	2,6E+4	5,0E+4	870
Pb-205	2,2E+4	3,3E+4	3,4E+4	3,4E+4	1,4E+7	2,9E+6	3,1E+7	2,1E+7	2,2E+4
Pb-210	3,4	9	10	9	1,1E+3	220	2,4E+3	1,6E+3	3,4
Pb-212	140	167	337	391	7,0E+4	1,1E+4	5,6E+3	1,0E+4	140
Pd-103	9,5E+3	9,5E+3	1,8E+4	2,2E+4	6,8E+6	9,9E+5	3,3E+5	6,2E+5	9,5E+3
Pd-107	1,3E+5	2,5E+5	2,5E+5	2,5E+5	5,5E+7	1,1E+7	1,2E+8	8,2E+7	1,3E+5
Pd-109	3,8E+3	3,9E+3	4,4E+3	4,5E+3	8,6E+6	1,3E+6	5,0E+5	9,4E+5	3,8E+3
Pm-143	817	812	1,9E+3	2,5E+3	8,1E+5	9,7E+4	2,4E+4	4,5E+4	812
Pm-144	167	167	391	523	1,6E+5	2,0E+4	4,8E+3	9,2E+3	167
Pm-145	3,3E+3	5,6E+3	1,2E+4	1,3E+4	1,1E+6	2,0E+5	1,8E+5	3,1E+5	3,3E+3
Pm-147	3,6E+3	1,6E+4	1,8E+4	1,7E+4	9,3E+5	1,9E+5	2,1E+6	1,4E+6	3,6E+3
Pm-148m	126	126	281	370	1,5E+5	1,7E+4	3,8E+3	7,2E+3	126
Pm-149	3,4E+3	3,7E+3	4,1E+3	4,1E+3	5,7E+6	9,8E+5	6,4E+5	1,1E+6	3,4E+3
Pm-151	654	650	1,2E+3	1,5E+3	9,5E+5	1,1E+5	2,3E+4	4,4E+4	650
Po-210	6	28	31	29	1,4E+3	287	3,1E+3	2,1E+3	6
Pr-142	2,6E+3	2,6E+3	3,7E+3	4,0E+3	3,8E+6	5,1E+5	1,4E+5	2,7E+5	2,6E+3
Pr-143	2,8E+3	3,9E+3	3,9E+3	3,9E+3	2,1E+6	4,3E+5	4,7E+6	3,2E+6	2,8E+3
Pt-188	161	160	363	484	2,1E+5	2,3E+4	4,7E+3	9,1E+3	160
Pt-191	887	879	2,0E+3	2,6E+3	1,2E+6	1,3E+5	2,7E+4	5,1E+4	879
Pt-193	2,0E+5	2,4E+5	2,5E+5	2,4E+5	2,2E+8	4,5E+7	4,9E+8	3,3E+8	2,0E+5
Pt-193m	7,2E+3	7,2E+3	8,6E+3	8,9E+3	1,8E+7	2,5E+6	7,3E+5	1,4E+6	7,2E+3
Pt-195m	1,9E+3	1,9E+3	2,6E+3	2,8E+3	4,3E+6	5,0E+5	1,1E+5	2,1E+5	1,9E+3
Pt-197	4,5E+3	4,5E+3	5,8E+3	6,1E+3	1,2E+7	1,5E+6	3,5E+5	6,6E+5	4,5E+3
Pt-197m	1,9E+3	1,9E+3	3,1E+3	3,6E+3	3,2E+6	3,6E+5	7,6E+4	1,5E+5	1,9E+3
Pu-236	1,1	12	17	14	233	47	513	347	1,1
Pu-237	5,7E+3	5,7E+3	1,2E+4	1,6E+4	5,0E+6	6,5E+5	1,8E+5	3,3E+5	5,7E+3
Pu-238	0,5	5	7	6	101	21	223	151	0,5
Pu-239	0,4	5	6	5	93	19	205	139	0,4
Pu-240	0,4	5	6	5	93	19	205	139	0,4
Pu-241	23	260	345	286	5,2E+3	1,1E+3	1,1E+4	7,7E+3	23
Pu-242	0,5	5	7	6	97	20	214	145	0,5
Pu-244	0,5	5	7	6	99	20	216	147	0,5
Ra-223	2,8	26	33	28	628	128	1,3E+3	920	2,8
Ra-224	6	48	59	53	1,5E+3	309	2,3E+3	2,0E+3	6
Ra-225	2,9	26	32	28	645	131	1,4E+3	950	2,9
Ra-226	2,2	7	7	7	619	126	1,1E+3	839	2,2
Ra-228	5	13	13	13	1,8E+3	357	2,7E+3	2,3E+3	5
Rb-81	416	412	903	1,2E+3	5,8E+5	6,1E+4	1,3E+4	2,4E+4	412
Rb-83	480	477	1,0E+3	1,3E+3	6,3E+5	7,0E+4	1,5E+4	2,9E+4	477
Rb-84	272	270	565	717	3,6E+5	4,0E+4	8,6E+3	1,6E+4	270
Rb-86	1,2E+3	1,2E+3	1,6E+3	1,7E+3	2,2E+6	2,9E+5	8,4E+4	1,6E+5	1,2E+3
Rb-87	3,0E+3	3,2E+3	3,2E+3	3,2E+3	9,3E+6	1,9E+6	2,1E+7	1,4E+7	3,0E+3
Re-184	292	290	656	867	3,4E+5	3,9E+4	8,7E+3	1,7E+4	290
Re-184m	235	234	500	632	2,1E+5	2,8E+4	7,3E+3	1,4E+4	234
Re-186	2,6E+3	2,9E+3	3,3E+3	3,4E+3	3,4E+6	5,9E+5	3,8E+5	6,7E+5	2,6E+3
Re-187	1,2E+6	1,9E+6	1,9E+6	1,9E+6	7,4E+8	1,5E+8	1,6E+9	1,1E+9	1,2E+6
Re-188	1,8E+3	1,8E+3	2,2E+3	2,4E+3	3,6E+6	4,8E+5	1,4E+5	2,6E+5	1,8E+3
Re-189	1,7E+3	1,7E+3	2,2E+3	2,4E+3	3,6E+6	4,5E+5	1,1E+5	2,2E+5	1,7E+3
Rh-99	424	421	952	1,3E+3	5,3E+5	5,8E+4	1,3E+4	2,4E+4	421

Nuclide	Derived Level Workers [Bq/cm²] W-SM	W-SR	W-LR	W-FF	Derived Level Public [Bq/cm²] P-SM	P-SR	P-LR	P-FF	Overall Min.
Rh-101	936	932	2,0E+3	2,5E+3	8,1E+5	1,1E+5	2,9E+4	5,5E+4	932
Rh-102	123	122	280	372	1,3E+5	1,6E+4	3,6E+3	6,9E+3	122
Rh-102m	502	500	1,1E+3	1,4E+3	4,4E+5	5,7E+4	1,6E+4	2,9E+4	500
Rh-103m	1,1E+5	1,1E+5	2,4E+5	3,1E+5	1,4E+8	1,6E+7	3,3E+6	6,4E+6	1,1E+5
Rh-105	2,6E+3	2,6E+3	4,6E+3	5,4E+3	3,5E+6	4,2E+5	9,9E+4	1,9E+5	2,6E+3
Rn-222	155	155	349	451	1,2E+5	1,6E+4	4,6E+3	8,8E+3	155
Ru-97	1,1E+3	1,1E+3	2,6E+3	3,5E+3	1,4E+6	1,5E+5	3,2E+4	6,2E+4	1,1E+3
Ru-103	516	513	1,2E+3	1,5E+3	5,2E+5	6,3E+4	1,5E+4	2,9E+4	513
Ru-105	290	288	634	829	3,9E+5	4,2E+4	8,8E+3	1,7E+4	288
Ru-106	352	560	764	781	1,5E+5	2,8E+4	3,3E+4	5,5E+4	352
S-35	6,5E+3	1,1E+4	1,1E+4	1,1E+4	3,3E+6	6,8E+5	7,3E+6	5,0E+6	6,5E+3
Sb-122	501	498	970	1,2E+3	6,7E+5	7,6E+4	1,7E+4	3,3E+4	498
Sb-124	145	144	322	421	1,6E+5	1,9E+4	4,4E+3	8,3E+3	144
Sb-125	536	535	1,1E+3	1,4E+3	4,0E+5	5,5E+4	1,7E+4	3,2E+4	535
Sb-126	94	93	211	280	1,2E+5	1,3E+4	2,8E+3	5,3E+3	93
Sc-44	124	123	277	369	1,7E+5	1,8E+4	3,7E+3	7,0E+3	123
Sc-46	135	134	310	413	1,4E+5	1,7E+4	3,9E+3	7,5E+3	134
Sc-47	2,0E+3	2,0E+3	3,6E+3	4,2E+3	2,3E+6	2,9E+5	7,5E+4	1,4E+5	2,0E+3
Sc-48	83	82	190	257	1,1E+5	1,1E+4	2,4E+3	4,6E+3	82
Se-75	603	599	1,2E+3	1,4E+3	7,8E+5	9,0E+4	2,0E+4	3,9E+4	599
Se-79	2,5E+3	2,9E+3	2,9E+3	2,9E+3	4,2E+6	8,6E+5	9,3E+6	6,3E+6	2,5E+3
Si-31	5,3E+3	5,4E+3	5,4E+3	5,4E+3	5,5E+7	1,0E+7	8,7E+6	1,5E+7	5,3E+3
Si-32	1,1E+3	4,5E+3	4,9E+3	4,6E+3	2,7E+5	5,6E+4	6,0E+5	4,1E+5	1,1E+3
Sm-145	3,1E+3	3,1E+3	6,8E+3	8,5E+3	1,7E+6	2,6E+5	9,3E+4	1,7E+5	3,1E+3
Sm-147	2,2	25	33	27	485	99	1,1E+3	723	2,2
Sm-151	5,1E+3	4,0E+4	4,8E+4	4,3E+4	1,2E+6	2,4E+5	2,6E+6	1,7E+6	5,1E+3
Sm-153	2,4E+3	2,4E+3	3,6E+3	3,9E+3	3,1E+6	4,1E+5	1,2E+5	2,2E+5	2,4E+3
Sn-113	849	845	1,9E+3	2,4E+3	7,0E+5	9,3E+4	2,6E+4	4,9E+4	845
Sn-117m	1,2E+3	1,2E+3	1,9E+3	2,1E+3	1,0E+6	1,5E+5	4,9E+4	9,2E+4	1,2E+3
Sn-119m	4,3E+3	6,7E+3	8,8E+3	9,0E+3	1,9E+6	3,6E+5	4,4E+5	7,2E+5	4,3E+3
Sn-121m	3,0E+3	7,5E+3	8,3E+3	8,2E+3	9,8E+5	1,9E+5	7,4E+5	8,8E+5	3,0E+3
Sn-123	1,1E+3	1,8E+3	1,8E+3	1,8E+3	5,7E+5	1,1E+5	6,0E+5	6,2E+5	1,1E+3
Sn-125	617	616	1,0E+3	1,1E+3	6,7E+5	9,1E+4	2,6E+4	5,0E+4	616
Sn-126	456	1,0E+3	1,2E+3	1,2E+3	1,6E+5	3,2E+4	9,7E+4	1,2E+5	456
Sr-82	1,4E+3	1,6E+3	1,6E+3	1,6E+3	2,2E+6	4,5E+5	4,9E+6	3,3E+6	1,4E+3
Sr-85	503	499	1,1E+3	1,5E+3	6,4E+5	7,0E+4	1,5E+4	2,8E+4	499
Sr-85m	1,3E+3	1,3E+3	3,0E+3	4,1E+3	1,7E+6	1,8E+5	3,7E+4	7,1E+4	1,3E+3
Sr-87m	818	811	1,9E+3	2,5E+3	1,1E+6	1,2E+5	2,4E+4	4,6E+4	811
Sr-89	2,0E+3	2,2E+3	2,2E+3	2,2E+3	4,6E+6	9,4E+5	8,7E+6	6,5E+6	2,0E+3
Sr-90	216	288	290	289	1,8E+5	3,7E+4	4,0E+5	2,7E+5	216
Sr-91	365	362	770	989	5,1E+5	5,5E+4	1,1E+4	2,2E+4	362
Sr-92	177	175	403	540	2,3E+5	2,5E+4	5,2E+3	9,9E+3	175
H-3	1,6E+5	2,3E+5	2,3E+5	2,3E+5	1,0E+8	2,1E+7	2,3E+8	1,5E+8	1,6E+5
Ta-178-l	263	261	617	843	3,4E+5	3,7E+4	7,5E+3	1,4E+4	261
Ta-179	7,7E+3	7,6E+3	1,7E+4	2,2E+4	7,1E+6	8,9E+5	2,3E+5	4,4E+5	7,6E+3
Ta-182	207	206	463	602	2,0E+5	2,4E+4	6,2E+3	1,2E+4	206
Tb-157	1,4E+4	4,0E+4	7,2E+4	7,4E+4	3,7E+6	7,1E+5	1,3E+6	1,9E+6	1,4E+4
Tb-158	215	305	668	766	8,3E+4	1,4E+4	9,4E+3	1,7E+4	215
Tb-160	239	238	525	676	2,2E+5	2,8E+4	7,3E+3	1,4E+4	238
Tc-95m	373	370	854	1,1E+3	4,6E+5	5,0E+4	1,1E+4	2,1E+4	370
Tc-96	106	105	243	327	1,4E+5	1,5E+4	3,1E+3	5,9E+3	105
Tc-96m	107	106	251	342	1,4E+5	1,5E+4	3,1E+3	5,9E+3	106
Tc-97	1,5E+4	1,5E+4	3,0E+4	3,6E+4	1,1E+7	1,5E+6	4,8E+5	9,1E+5	1,5E+4
Tc-97m	3,4E+3	6,4E+3	7,9E+3	7,9E+3	1,4E+6	2,7E+5	5,0E+5	7,4E+5	3,4E+3
Tc-98	177	176	381	487	1,7E+5	2,2E+4	5,4E+3	1,0E+4	176
Tc-99	3,6E+3	1,0E+4	1,1E+4	1,1E+4	1,2E+6	2,4E+5	2,6E+6	1,7E+6	3,6E+3
Tc-99m	2,3E+3	2,2E+3	5,2E+3	7,1E+3	2,9E+6	3,1E+5	6,5E+4	1,2E+5	2,2E+3
Te-121	445	441	1,0E+3	1,4E+3	5,6E+5	6,1E+4	1,3E+4	2,5E+4	441
Te-121m	946	959	1,8E+3	2,0E+3	6,6E+5	9,8E+4	3,5E+4	6,6E+4	946
Te-123m	1,3E+3	1,4E+3	2,5E+3	2,9E+3	7,9E+5	1,2E+5	5,2E+4	9,6E+4	1,3E+3

	Derived Level Workers [Bq/cm²]				Derived Level Public [Bq/cm²]				
Nuclide	W-SM	W-SR	W-LR	W-FF	P-SM	P-SR	P-LR	P-FF	**Overall Min.**
Te-125m	2,3E+3	3,1E+3	4,8E+3	5,1E+3	1,1E+6	2,0E+5	1,5E+5	2,6E+5	2,3E+3
Te-127	7,7E+3	7,8E+3	8,5E+3	8,6E+3	2,4E+7	3,7E+6	1,5E+6	2,9E+6	7,7E+3
Te-127m	1,4E+3	2,7E+3	3,1E+3	3,1E+3	6,0E+5	1,2E+5	2,9E+5	4,0E+5	1,4E+3
Te-129	2,5E+3	2,5E+3	3,7E+3	4,0E+3	5,6E+6	6,1E+5	1,3E+5	2,5E+5	2,5E+3
Te-129m	1,1E+3	1,4E+3	1,9E+3	2,0E+3	6,1E+5	1,1E+5	9,0E+4	1,6E+5	1,1E+3
Te-131m	106	106	186	217	1,4E+5	1,7E+4	4,1E+3	7,8E+3	106
Te-132	103	103	232	308	1,3E+5	1,4E+4	3,1E+3	5,9E+3	103
Th-227	2,1	25	35	28	465	95	1,0E+3	690	2,1
Th-228	0,5	5	7	6	108	22	229	159	0,5
Th-229	0,3	2,9	3,8	3,2	59	12	131	89	0,3
Th-230	1,5	14	17	15	332	68	733	495	1,5
Th-231	8,1E+3	8,2E+3	1,1E+4	1,2E+4	8,8E+6	1,3E+6	4,9E+5	9,2E+5	8,1E+3
Th-232	0,9	9	11	10	186	38	410	277	0,9
Th-nat	0,3	2,6	3,3	2,9	66	13	139	97	0,3
Th-234	1,0E+3	1,6E+3	1,7E+3	1,6E+3	5,9E+5	1,2E+5	3,1E+5	4,2E+5	1,0E+3
Ti-44	111	111	244	305	6,5E+4	9,6E+3	3,4E+3	6,3E+3	111
Tl-200	211	209	497	680	2,7E+5	2,9E+4	6,0E+3	1,2E+4	209
Tl-201	2,9E+3	2,9E+3	6,4E+3	8,5E+3	3,9E+6	4,2E+5	8,8E+4	1,7E+5	2,9E+3
Tl-202	559	554	1,3E+3	1,7E+3	7,3E+5	7,8E+4	1,6E+4	3,1E+4	554
Tl-204	3,8E+3	4,1E+3	4,2E+3	4,2E+3	1,2E+7	2,3E+6	5,7E+6	7,9E+6	3,8E+3
Tm-167	1,3E+3	1,3E+3	2,3E+3	2,6E+3	1,5E+6	2,0E+5	5,2E+4	9,8E+4	1,3E+3
Tm-170	1,7E+3	3,5E+3	3,6E+3	3,6E+3	6,6E+5	1,3E+5	7,3E+5	7,3E+5	1,7E+3
Tm-171	1,2E+4	4,8E+4	5,2E+4	5,0E+4	3,3E+6	6,7E+5	4,4E+6	4,0E+6	1,2E+4
U-230	1,3	15	21	17	290	59	638	432	1,3
U-232	0,3	3,0	3,9	3,3	61	12	132	91	0,3
U-233	2,3	25	33	28	485	99	1,1E+3	723	2,3
U-234	2,3	26	34	28	495	101	1,1E+3	738	2,3
U-235	2,6	28	37	31	547	111	1,2E+3	809	2,6
U-236	2,5	28	37	31	535	109	1,2E+3	797	2,5
U-238	2,7	29	39	32	581	118	1,3E+3	865	2,7
U-nat	0,5	3,4	3,9	3,6	119	24	248	173	0,5
V-48	93	92	209	278	1,2E+5	1,3E+4	2,7E+3	5,2E+3	92
V-49	2,6E+5	4,1E+5	4,1E+5	4,1E+5	1,4E+8	2,8E+7	3,0E+8	2,0E+8	2,6E+5
W-178	2,2E+3	2,1E+3	4,8E+3	6,4E+3	2,8E+6	3,1E+5	6,4E+4	1,2E+5	2,1E+3
W-181	6,2E+3	6,2E+3	1,4E+4	1,8E+4	8,2E+6	8,9E+5	1,9E+5	3,6E+5	6,2E+3
W-185	9,8E+3	1,0E+4	1,1E+4	1,0E+4	3,9E+7	7,8E+6	6,7E+7	5,3E+7	9,8E+3
W-187	512	508	1,1E+3	1,4E+3	7,1E+5	7,7E+4	1,6E+4	3,1E+4	508
W-188	1,4E+3	1,4E+3	1,7E+3	1,7E+3	2,5E+6	3,7E+5	1,3E+5	2,5E+5	1,4E+3
Y-87	336	333	778	1,1E+3	4,3E+5	4,6E+4	9,7E+3	1,9E+4	333
Y-88	110	109	256	347	1,3E+5	1,4E+4	3,1E+3	6,0E+3	109
Y-90	1,8E+3	2,0E+3	2,0E+3	2,0E+3	3,3E+6	6,8E+5	7,3E+6	5,0E+6	1,8E+3
Y-91	1,3E+3	2,2E+3	2,2E+3	2,2E+3	6,5E+5	1,3E+5	8,8E+5	8,0E+5	1,3E+3
Y-91m	500	495	1,2E+3	1,6E+3	6,5E+5	6,9E+4	1,4E+4	2,7E+4	495
Y-92	637	634	952	1,1E+3	1,4E+6	1,5E+5	3,2E+4	6,0E+4	634
Y-93	1,3E+3	1,3E+3	1,7E+3	1,8E+3	3,1E+6	3,8E+5	9,3E+4	1,8E+5	1,3E+3
Yb-169	746	743	1,5E+3	1,9E+3	7,0E+5	9,1E+4	2,4E+4	4,6E+4	743
Yb-175	4,1E+3	4,1E+3	6,4E+3	7,0E+3	4,0E+6	5,7E+5	1,9E+5	3,6E+5	4,1E+3
Zn-65	406	404	792	967	5,0E+5	5,9E+4	1,4E+4	2,6E+4	404
Zn-69	8,3E+3	8,4E+3	8,4E+3	8,4E+3	1,7E+8	3,4E+7	2,8E+8	2,2E+8	8,3E+3
Zn-69m	622	617	1,4E+3	1,9E+3	7,9E+5	8,6E+4	1,8E+4	3,5E+4	617
Zr-88	676	672	1,6E+3	2,1E+3	6,0E+5	7,6E+4	2,0E+4	3,7E+4	672
Zr-93	2,0E+3	1,4E+4	1,6E+4	1,5E+4	4,7E+5	9,5E+4	1,0E+6	6,9E+5	2,0E+3
Zr-95	348	346	783	1,0E+3	3,2E+5	4,0E+4	1,0E+4	2,0E+4	346
Zr-97	164	163	356	464	2,2E+5	2,4E+4	5,0E+3	9,6E+3	163