Strahlenschutzkommission

Geschäftsstelle der
Strahlenschutzkommission
Postfach 12 06 29
D-53048 Bonn

http://www.ssk.de

Measures to be Taken in Cases of Radioactive Contamination of the Skin

Recommendation of the German Commission on Radiological Protection

Adopted at the 92nd session of the Commission on Radiological Protection on September 22, 1989

The German original of this English translation was published in Volume 15
of the series “Publications by the Commission on Radiological Protection”
under the title:

Maßnahmen bei radioaktiver Kontamination der Haut

Empfehlung der Strahlenschutzkommission

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

Table of Contents

1 Introduction

Sec. 64, para. (3) of the Radiological Protection Ordinance (Strahlenschutzverordnung, StrlSchV), as amended on June 30, 1989, calls for measures to be taken where persons have been contaminated with radioactive substances. Annex IX contains limits for protective measures where surface contamination of workplaces and objects has occurred; it does not contain any limits for skin decontamination measures. However, radiological protection does in practice require at least guideline values in order to prevent unsuitable or detrimental decontamination measures which could harm the skin or encourage incorporation. New calculations of dose equivalent rate factors for the skin now make the recommendation of guideline values possible. Moreover, recent findings on the intake of radioactive substances into the skin are taken into account.

This recommendation refers to those technical, medical and scientific facilities in which unsealed radioactive substances are handled in accordance with the Atomic Energy Act and the Radiological Protection Ordinance.

These facilities include, among other things:

- Nuclear power plants,
- Facilities of the fuel cycle,
- Scientific and industrial laboratories,
- Doctors' practices, hospitals and medical laboratories.

In order to enable them to carry out specific measures, people working in radiological protection and authorized physicians (company physicians) require special knowledge on the decontamination of persons.

In accordance with Sec. 28, para. (1) and Sec. 53, para. (1) of the Radiological Protection Ordinance, the following important principles must be observed when working with unsealed radioactive substances:

Any unnecessary contamination of individuals shall be avoided.

If contamination does occur, the resulting radiation exposure shall be kept as low as possible, even below the dose limits of the Radiological Protection Ordinance, taking into consideration the state of the art and also taking into account all circumstances pertaining to each individual case.

Wherever there is a possibility of contamination, adherence to this principle calls for meaningful measures in order to keep the skin dose at a low level.

This recommendation does not refer to emergency or disaster control measures, nor does it address the medical treatment of contaminated wounds.

2 Derivation of a Guideline Value for Measures where Skin Contamination has Occurred

2.1 Determination of the skin dose

Corresponding dose equivalent rate factors for various radionuclides are available for determining the skin dose (calculated according to Appendix 1) caused by skin contamination. These dose equivalent rate factors take into account all contributions from the types of radiation emitted (α, β, γ, and AUGER radiation). Appendix 2 lists these dose equivalent rate factors for 611 radionuclides. The local skin dose can be calculated by multiplying these dose equivalent rate factors with the surface-related activity on the skin (in Bq/cm^2) and with the duration of contamination (in seconds), taking into account the respective half life. When calculating the dose equivalent rate factors it is assumed that the layer of the skin regarded as sensitive to radiation is usually 50 - 100 µm below the surface. This assumption produces slightly higher dose equivalent rate factors than if a skin depth of 70 µm was used.

Radioactive substances can penetrate the horny layer of the epidermis, although the activity concentration falls very quickly as the depth of the horny layer increases (exponentially with a half-value thickness of around 2 µm). Such penetration thus has only an insignificant effect on the dose in the layer of skin regarded as sensitive to radiation. The spatial activity distribution in the horny layer is therefore not taken into account when calculating the dose equivalent rate factors.

When establishing a guideline value to serve as a basis for deciding on further decontamination measures it must be assumed that the activity concentration falls exponentially with the depth of the horny layer. Since this layer undergoes full exfoliation within two weeks there is a very rapid exponential decrease in the activity remaining on the skin. Thus, the retention time of one week used when calculating the dose considerably overestimates the actual dose.

2.2 Derivation of a guideline value

The primary limit for skin contamination in any one calendar year of 300 mSv as specified in Annex X, Table X1, No. 3, Column 2 of the Radiological Protection Ordinance is used as a basis when deriving a guideline value. The higher limit of 500 mSv per calendar year as specified in No. 4 for the partial body dose of the hands, forearms, feet, lower legs and ankles, including the respective skin, is not used in this context.

A uniform guideline value for surface-related activity of 10 Bq/cm^2 is established for skin contamination remaining after certain decontamination steps have been carried out. Further decontamination measures are not required below this value. This means that for more than 90 % of the nuclides listed, including those of relevance to radiological protection, less than 1 % of the aforementioned annual dose limit is reached with a retention time of one week. Moreover, with one exception (Cf 254), all doses are less than 5 % of this limit. The doses are even significantly lower if contamination is quickly and fully eliminated.

The establishment of this guideline value takes into account the fact that even where several cases of contamination that cannot be eliminated occur in one calendar year, the levels are still sufficiently below the limits stipulated in the Radiological Protection Ordinance (even for people in Category B). Thus, any contributions from radioactive daughter nuclides which are not included in the contamination measurement are covered for, as are possible uncertainties regarding the dose determination.

The following table quotes examples of values for surface-related activity which, given the half-lives with the aforementioned retention time of one week, result in a skin dose of 1 % of this annual dose limit of 300 mSv.

Nuclide	Surface-related activity (Bq/cm^2)
C 14	100
Co 60	20
Sr 90	10
Y 90	25
I 131	20
Cs 137	10
Ce 141	10

The uniform guideline value of 10 Bq/cm^2 should also be applied to those radionuclides which, due to the short range of their radiation, do not make any contribution to the dose of the layer of skin regarded as radio-sensitive. This constitutes sufficient provision against risks caused by the spreading of radioactive substances outside the controlled area. In this context, it is assumed that cases of persistent residual contamination are very rare and that any remaining activity adheres firmly to the skin. Special reflection is necessary where contamination spreads beyond the surface of a person's head or hands.

In addition to causing radiation of the skin, radionuclides in the horny layer of the epidermis can also lead to exposure of other parts of the body:

- the radiation from the activity in the horny layer can expose other parts of the body,
- the radioactive substances can reach body fluids by means of permeation and can thus be distributed throughout the body.

These types of exposure are not important when establishing a guideline value for decontamination:

- as shown by the calculation of corresponding doses, the irradiation of other parts of the body by photon radiation from the horny layer is negligible compared with skin exposure;
- permeation can hardly be influenced by later decontamination measures. An assessment of this permeation with respect to incorporation is presented in the following section.

3 Transport of Radioactive Substances into and through the Skin

3.1 Transport process

The skin represents an effective, but not completely impenetrable barrier against radioactive substances. While solid particles, assisted by rubbing, can penetrate the skin mechanically, liquids are subject to capillary forces and diffusion. As long as a liquid wets the surface of the skin, substances are transported from the surface into and through the skin. This produces both a (temporary) deposition of activity in the horny layer and transportation to deeper layers of the skin, and may possibly result in uptake into the blood.

The ability of the horny layer to absorb the contaminating liquid is exhausted within a few minutes. This layer absorbs around one microliter of liquid per square centimeter of wet surface, and thus the activity contained therein. The activity absorbed by the horny layer during this process is thus proportional to the activity concentration of the liquid and to the size of the area of skin affected. However, the horny layer does have a special affinity for certain substances. This can lead to an accumulation of radioactivity in the horny layer if contamination persists.

The transport maintained by a liquid on the surface of the skin through the skin itself (permeation) is also proportional to the activity concentration in the liquid and the size of the area of skin affected, as well as to the length of time the contaminating liquid is on the skin. In the case of inorganic substances, organic acids, salts, and lipophilic compounds dissolved in water, the amount of substance transported through the skin per square centimeter and hour is the same as that contained in 0.001 to 0.1 µl of solution. The rate of permeation is considerably higher for gases or highly volatile

3.2 Consequences

Even if to a varying degree, the length of time a radioactive solution remains on the surface of the skin plays a role in both of the aforementioned processes. This means that by removing the contaminating liquids as quickly as possible, any further deposition of activity in the skin is halted and permeation through the skin reduced.

Only the very external intercellular spaces of the horny layer – which apart from on the palms of the hands and the soles of the feet is only around 15 µm thick – can be decontaminated by means of simple measures. Once substances have penetrated further into the horny layer they can no longer be removed completely without drastic measures and damage to the skin. At worst, up to 50 % of the original activity may remain. On the other hand, the horny layer completely regenerates itself within 14 days, shedding the horny cells together with the substances embedded within.

The fact that permeation of radioactivity through the skin is possible means that incorporation can play a role where a very large area of the body is affected and where there is a long period of contamination with high activity concentrations. Here, it should be noted that the rate of transfer into the blood may be so low that the incorporated activity cannot be determined metrologically or can only be determined with great difficulty.

4 Preventive Measures

4.1 General measures

Preventive measures to avoid or limit contamination represent the most effective form of protection.

In principle, a healthy skin offers the best protection against percutaneous incorporation of radioactive substances. Special care must therefore be taken that all those who handle unsealed radioactive substances have skin that is well looked after and intact. This applies in particular to the hands, since cracks in the surface of the skin represent openings which could facilitate incorporation.

Preventive measures therefore include regular checks on the condition of the skin and constant personal skin care.

The condition of the skin should be checked as follows:

- during the annual medical checkup of occupationally exposed persons by the authorized physician (company physician). Here, a person's suitability for working with unsealed radioactive substances is assessed, with particular attention being paid to the present and chronic condition of the skin;
- self-monitoring by occupationally exposed persons who have been instructed as to the importance of intact skin when working with unsealed radioactive substances; when in doubt, a person should consult the authorized physician acquainted with the plant in question;
- monitoring by the radiological protection officer, who arranges for a person to be examined by the authorized physician acquainted with the plant in question where recognizable skin defects or diseases are detected.

Pursuant to Sec. 53, para. (2) of the Radiological Protection Ordinance, the following points in particular should be highlighted during the regular instruction sessions on behaviour in the controlled area:

- No smoking.
- No eating or drinking.
- Avoid spreading contamination in any case. Therefore,
  - do not touch anything thoughtlessly,
  - do not walk around unnecessarily,
  - do not raise any dust,
  - do not spread any liquids.

It is recommended that these points be stressed at the regular instruction sessions on radiological protection, with reference being made to the special operating conditions. This is intended to encourage preventive health protection. In particular, individuals who do not work full-time at the plant should be made to understand why it is important for the skin to remain intact.

4.2 Special measures

Preventive measures to protect individuals depend on whether contamination may be caused by particulate, oily or water-soluble substances. The risk depends, among other things, on:

- the type of nuclide and its chemical form,
- the activity concentration or specific activity,
- the solubility,
- the position and expanse of the part of the skin which may be affected.

In individual cases, protective measures which are specific to the respective workplace must be applied and adapted to the expected risk.

4.2.1 Individual protective equipment

Protective clothing (such as gloves and protective suits, and in special cases even fully protective suits) may be necessary. It must be ensured that the protective clothing meets the required standard of protection, with special care being taken that the mechanical load capability corresponds to the expected risk and the requirements of the work to be performed.

One of the most common causes of contamination is the transfer of radioactive substances from protective clothing onto unprotected areas of skin. For example, contaminated gloves often touch unprotected parts of the body such as the face. The regular instruction sessions in particular should be used to teach people to avoid such errors.

Another source of contamination is the incorrect removal of contaminated protective clothing. The removal of protective clothing must be trained – where applicable with the aid of an assistant.

4.2.2 Measures to protect the skin

It is recommended that special skin-protective pastes be used when working with greases, oils, and aqueous solutions that contain radionuclides. These pastes facilitate gentle cleansing and decontamination.

5 Decontamination Measures

5.1 Organizational provisions

Contamination must always be considered a possibility when working with unsealed radioactive substances. Organizational measures and practical procedures for decontaminating individuals must therefore be provided for.

Specific decontamination instructions must be provided for each individual plant and also, where applicable, for each individual workplace.

5.2 Pre-decontamination measures

Contaminated items of clothing must be removed – where applicable with the aid of an assistant – before decontamination is commenced.

Special care must be taken that no other parts of the skin are contaminated in the process, and that no particulate contamination enters the air. The assistant must therefore wear appropriate protective clothing (e.g. gloves, protective suit).

Suitable containers should be available for contaminated clothing and for solid and liquid radioactive wastes.

5.3 Decontamination process

Simple opportunities for decontamination which can be implemented immediately and everywhere must be available. Where applicable, swift decontamination measures should take priority over establishing the level of skin contamination by measuring the activity.

The immediate application of lukewarm water, special soaps or washing lotions (where applicable using soft hand brushes) usually results in a rapid elimination of the contamination.

Low levels of contamination can usually be eliminated in one step by washing with water.

Wherever possible, only the contaminated areas of skin (e.g. the palms of the hand) should be washed with lukewarm water.

The washing process should be completed after around two minutes, and the skin should then be dried carefully using an absorbent material. Sec. 5.5 should be followed if any contamination remains.

Decontamination should be commenced as quickly as possible in view of the fact that both the activity concentration of a contaminating liquid and the exposure time are the main parameters determining skin permeation.

It must be noted that the low level of incorporation as a result of permeation may benefit from washing. Such incorporation plays only a minor role if the contamination is immediately eliminated by washing. Even the often feared secondary contamination of adjacent areas of skin through washing is fairly negligible in practice since the concentration of the radionuclides is significantly reduced and the exposure time kept short if sufficient water is used.

Where radionuclides are part of special chemical compounds or preparations it may be necessary to provide for specific decontamination procedures if this results in improved decontamination and less skin permeation. Organic solvents must not be used. Decontamination foam used for material surfaces is also unsuitable, given the skin irritations it can cause.

5.4 Decontamination of specific parts of the body

5.4.1 Hair

If hair becomes contaminated it should be washed at a suitable hair wash bowl with the head leaning backwards. The hair should be washed with detergent by an assistant wearing gloves. The hair should then be rinsed thoroughly with plenty of water. When washing the hair, care should be taken that no contaminated water comes into contact with the face, eyes, or ears.

A control measurement should be taken using a contamination monitor before the hair is dried.

Where cutting the hair is clearly preferable to washing, this should be agreed with the person concerned.

5.4.2 Eyes

If a person's eyes become contaminated they should be rinsed properly with plenty of water. Any further measures should be at the discretion of a physician.

5.4.3 Mouth, nose, ears

An authorized physician and, where necessary, an ear-, nose- and throat-specialist should be consulted if contamination of the mouth, nasopharynx or auditory canal occurs.

The mouth should be decontaminated by rinsing with plenty of water. Contamination of the nasal cavities can be reduced by blowing-one's nose.

In principle, the possibility of incorporation must be considered where contamination of the mouth, nose or ears occurs. The rinsing liquid used and secretory products should be kept for measurement.

5.4.4 Skin creases, grooves of the nail bed and fingernails

Where contamination is detected in skin creases, in the grooves of the nail bed or under the fingernails, it should be carefully removed. Simple instruments such as nailcleaners, soft brushes or adhesive strips can be used for this purpose.

5.5 Procedure if contamination persists

If the first decontamination process (cf. Sec. 5.3) proves unsuccessful it should be repeated up to two further times and the respective decontamination effect measured.

There is no need to carry out further decontamination steps where the decontamination effect is less than 10 % and the remaining surface-related activity is less than 10 Bq/cm^2 (averaged over 100 cm^2 where the contamination is largely distributed over the entire area).

Further washing should be carried out where the decontamination effect is greater than 10%, provided the condition of the skin allows.

The following procedure should be observed where the above criteria make it necessary to terminate the decontamination process but where the surface-related activity is still more than 10 Bq/cm^2:

- Consult the radiological protection officer and the authorized physician,
- Estimate the skin dose,
- Decide on further decontamination measures,
- Draw up a record containing the following information:
  - Name/department,
  - Time of contamination and decontamination measures carried out,
  - Contaminated part of the body,
  - Area of contamination (in cm^2),
  - Initial and residual values of the surface-related activity (in Bq/cm^2),
  - Nuclide composition,
  - Decontamination agents used,
  - Resulting skin dose,
  - Conditions imposed on and to be met by the person concerned before he/she is released.

The possibility of incorporation through the skin must be considered (see Sec. 3), as must the possibility of radioactive substances being spread where the contamination covers a large area.

6 Possible Radiation Exposure of Medical Staff when Treating Contaminated Patients

6.1 Problem

In the past, isolated cases of injured or sick people who had suffered contamination had to be given medical treatment. Occasionally, there was uncertainty as to the resulting radiation exposure and possible contamination of physicians and paramedical staff who treated such cases. This stemmed from the uncertainty surrounding the level of possible radiation exposure.

6.2 Possible radiation exposure

An analysis of assumed accidents revealed that contamination usually only reaches such a level that the resulting external exposure of physicians and paramedical staff when treating contaminated patients is a few millisieverts per hour. In most cases it is considerably less.

6.3 Precautionary measures for medical staff

As a rule, it can be assumed that patients have already been decontaminated by the time they are admitted to hospital and they can thus be expected to carry only slight contamination. Special precautionary measures are therefore not required.

Precautionary measures for staff may only be necessary in isolated cases – if, for example, decontamination is not possible where there is a vital indication. Normal surgical clothing provides sufficient protection. Incorporation can be prevented by wearing an ordinary face mask.

Removal of the patient's contaminated clothing is a very effective decontamination measure. Contaminated clothing and any objects that may have been contaminated must be collected in suitable containers.

Appendix 1

Calculation of the Dose Equivalent of the Contaminated Skin

The dose equivalent of the contaminated skin can be determined using the following equation:

$$H_S = A_F \cdot T_{1/2} \cdot \frac{1}{\ln 2} \cdot 86400 \cdot \left(1 - e^{-\frac{\ln 2}{T_{1/2}} \cdot t}\right) \cdot \dot{h}_S$$

H_S dose equivalent of the contaminated skin in Sv,

A_F surface-related activity in Bq/cm^2,

$T_{1/2}$ half life in days (d),

t duration of contamination in days (d),

$\dot{h}_S$ dose equivalent rate factor in Sv/s divided by Bq/cm^2 (see Appendix 2).

The factor 86 400 results from the conversion of days into seconds (s/d).

The following results on the basis of the above equation:

$$H_S = 1.25 \cdot 10^5 \cdot A_F \cdot T_{1/2} \cdot \left(1 - e^{-0.693 \frac{t}{T_{1/2}}}\right) \cdot \dot{h}_S$$

If a retention time of one week is postulated for contamination, the above equation takes the following simpler form for long-lived nuclides (i.e. nuclides whose half life is essentially longer than 7 d):

$$H_S = A_F \cdot 86\,400 \cdot 7 \cdot \dot{h}_S = A_F \cdot 604\,800 \cdot \dot{h}_S$$

Appendix 2

Dose Equivalent Rate Factors in Cases of Skin Contamination

The dose equivalent rate factor $\dot{h}_S$ of a superficial contamination of the skin is defined as follows:

The numerical value of $\dot{h}_S$ corresponds to the dose equivalent rate in Sv/s of the contaminated skin in the case of a surface-related activity of 1 Bq/cm^2.

When determining these values, the average was obtained by an integration over a skin depth of between 50 and 100 µm. In doing so, the contributions of γ, β and electron radiation were taken into consideration.

When calculating the contribution of γ radiation to the skin dose, a contamination of the entire surface of the skin was postulated.

Nuclide		$\dot{h}_s$	Nuclide		$\dot{h}_s$
H	3	<1.E-14	V	48	3.E-10
Be	7	<1.E-14	V	49	1.E-12
Be	10	5.E-10	Cr	48	1.E-11
C	14	5.E-11	Cr	51	1.E-12
F	18	5.E-10	Mn	52	2.E-10
Na	22	5.E-10	Mn	53	<1.E-14
Na	24	4.E-10	Mn	54	2.E-11
Mg	28	5.E-10	Mn	56	4.E-10
Al	26	5.E-10	Fe	52	3.E-10
Si	31	6.E-10	Fe	55	1.E-12
Si	32	2.E-10	Fe	59	3.E-10
P	32	6.E-10	Fe	60	4.E-11
P	33	2.E-10	Co	55	6.E-10
S	35	3.E-11	Co	56	1.E-10
Cl	36	5.E-11	Co	57	1.E-11
Ar	37	5.E-13	Co	58	9.E-11
Ar	39	5.E-10	Co	58 m	2.E-12
Ar	41	6.E-10	Co	60	3.E-10
K	40	5.E-10	Co	61	6.E-10
K	42	7.E-10	Ni	56	5.E-12
K	43	5.E-10	Ni	57	2.E-10
Ca	41	1.E-12	Ni	59	2.E-12
Ca	45	2.E-10	Ni	63	<1.E-14
Ca	47	5.E-10	Ni	65	4.E-10
Sc	43	4.E-10	Ni	66	2.E-10
Sc	44	6.E-10	Cu	61	4.E-10
Sc	44 m	5.E-12	Cu	64	3.E-10
Sc	46	3.E-10	Cu	67	4.E-10
Sc	47	4.E-10	Zn	62	4.E-11
Sc	48	5.E-10	Zn	65	2.E-11
Ti	44	2.E-11	Zn	69 m	3.E-11
Ti	45	5.E-10	Zn	71 m	6.E-10

Nuclide		$\dot{h}_s$
Zn	72	3.E-10
Ga	66	6.E-10
Ga	67	9.E-11
Ga	68	5.E-10
Ga	72	2.E-10
Ga	73	6.E-10
Ge	66	1.E-10
Ge	68	2.E-12
Ge	69	2.E-10
Ge	71	2.E-12
Ge	75	6.E-10
Ge	77	6.E-10
Ge	78	5.E-10
As	71	2.E-10
As	72	5.E-10
As	73	5.E-12
As	74	4.E-10
As	76	6.E-10
As	77	5.E-10
As	78	7.E-10
Se	73	5.E-10
Se	75	4.E-11
Se	79	9.E-11
Br	75	6.E-10
Br	76	6.E-10
Br	77	2.E-11
Br	80 m	5.E-12
Br	82	4.E-10
Br	83	5.E-10
Kr	76	3.E-12
Kr	77	6.E-10
Kr	79	4.E-11
Kr	81	3.E-12
Kr	83 m	1.E-12
Kr	85	5.E-10
Kr	85 m	5.E-10
Kr	87	7.E-10
Kr	88	5.E-10
Rb	81	3.E-10
Rb	82 m	1.E-10
Rb	83	3.E-11
Rb	84	2.E-10
Rb	86	4.E-10
Rb	87	3.E-10
Sr	80	3.E-12
Sr	82	<1.E-14
Sr	83	1.E-10
Sr	85	4.E-12
Sr	85 m	8.E-12
Sr	87 m	1.E-10
Sr	89	4.E-10

Nuclide		$\dot{h}_s$	
Sr	90	5.E-10	
Sr	91	4.E-10	
Sr	92	4.E-10	
Y	86	5.E-10	
Y	87	2.E-12	
Y	88	1.E-12	
Y	90	4.E-10	
Y	90 m	7.E-11	
Y	91	4.E-10	
Y	92	4.E-10	
Y	93	4.E-10	
Zr	86	3.E-11	
Zr	88	2.E-11	
Zr	89	4.E-10	
Zr	93	<1.E-14	
Zr	95	3.E-10	
Zr	97	4.E-10	
Nb	89	5.E-10	half life: 1.1 h
Nb	89	6.E-10	half life: 2.0 h
Nb	90	5.E-10	
Nb	93 m	4.E-12	
Nb	94	4.E-10	
Nb	95	6.E-11	
Nb	95 m	4.E-10	
Nb	96	5.E-10	
Nb	97	6.E-10	
Mo	90	3.E-10	
Mo	93	3.E-12	
Mo	93 m	2.E-10	
Mo	99	4.E-10	
Tc	93	4.E-13	
Tc	94	7.E-11	
Tc	95	1.E-12	
Tc	95 m	2.E-11	
Tc	96	2.E-12	
Tc	97	3.E-12	
Tc	97 m	1.E-10	
Tc	98	4.E-10	
Tc	99	3.E-10	
Tc	99 m	5.E-11	
Ru	97	2.E-11	
Ru	103	2.E-10	
Ru	105	4.E-10	
Ru	106	<1.E-14	
Rh	99	1.E-10	
Rh	99 m	4.E-11	
Rh	100	4.E-11	
Rh	101	7.E-11	
Rh	101 m	3.E-11	
Rh	102	3.E-12	
Rh	102 m	8.E-11	

Nuclide		$\dot{h}_s$	
Rh	105	3.E-10	
Rh	106 m	4.E-10	
Pd	100	6.E-11	
Pd	101	6.E-11	
Pd	103	2.E-12	
Pd	107	<1.E-14	
Pd	109	1.E-09	
Ag	103	2.E-10	
Ag	104	1.E-10	
Ag	105	1.E-11	
Ag	106 m	1.E-11	
Ag	108 m	4.E-11	
Ag	110 m	1.E-10	
Ag	111	4.E-10	
Ag	112	7.E-10	
Cd	107	2.E-10	
Cd	109	2.E-10	
Cd	113	3.E-10	
Cd	113 m	5.E-10	
Cd	115	5.E-10	
Cd	115 m	6.E-10	
Cd	117	6.E-10	
Cd	117 m	5.E-10	
In	109	8.E-11	
In	110	3.E-12	half life: 4.9 h
In	110	4.E-10	half life: 1.2 h
In	111	7.E-11	
In	113 m	2.E-10	
In	114 m	4.E-10	
In	115	4.E-10	
In	115 m	3.E-10	
In	117 m	5.E-10	
Sn	110	2.E-11	
Sn	113	4.E-13	
Sn	117 m	4.E-10	
Sn	119 m	1.E-10	
Sn	121	3.E-10	
Sn	121 m	8.E-11	
Sn	123	6.E-10	
Sn	125	6.E-10	
Sn	126	4.E-10	
Sn	127	6.E-10	
Sb	116 m	3.E-10	
Sb	117	6.E-11	
Sb	118 m	3.E-11	
Sb	119	2.E-12	
Sb	120	8.E-11	
Sb	122	6.E-10	
Sb	124	4.E-10	
Sb	125	2.E-10	
Sb	126	4.E-10	
Sb	127	4.E-10	
Sb	128	7.E-10	
Sb	129	4.E-10	
Te	116	1.E-10	
Te	121	2.E-12	
Te	121 m	2.E-10	
Te	123	2.E-13	
Te	123 m	2.E-10	
Te	125 m	3.E-10	
Te	127	4.E-10	
Te	127 m	2.E-10	
Te	129	4.E-10	
Te	129 m	3.E-10	
Te	131 m	4.E-10	
Te	132	1.E-10	
I	120	7.E-10	
I	121	3.E-10	
I	123	1.E-10	
I	124	5.E-10	
I	125	4.E-12	
I	126	4.E-10	
I	129	6.E-11	
I	130	5.E-10	
I	131	4.E-10	
I	132	4.E-10	
I	132 m	1.E-10	
I	133	4.E-10	
I	135	4.E-10	
Xe	122	7.E-12	
Xe	123	3.E-10	
Xe	125	6.E-11	
Xe	127	5.E-11	
Xe	129 m	4.E-10	
Xe	131 m	4.E-10	
Xe	133	4.E-10	
Xe	133 m	5.E-10	
Xe	135	5.E-10	
Cs	127	5.E-11	
Cs	129	5.E-12	
Cs	131	2.E-12	
Cs	132	4.E-12	
Cs	134	3.E-10	
Cs	134 m	4.E-10	
Cs	135	2.E-10	
Cs	136	4.E-10	
Cs	137	4.E-10	
Ba	126	1.E-11	
Ba	128	5.E-12	
Ba	131	1.E-10	

Nuclide		$\dot{h}_s$	Nuclide		$\dot{h}_s$	
Ba	133	6.E-11	Eu	147	4.E-11	
Ba	133 m	5.E-10	Eu	148	1.E-11	
Ba	135 m	4.E-10	Eu	149	4.E-12	
Ba	137 m	5.E-11	Eu	150	4.E-11	half life: 34 a
Ba	139	4.E-10	Eu	150	5.E-10	half life: 13 h
Ba	140	4.E-10	Eu	152	2.E-10	
La	132	2.E-10	Eu	152 m	3.E-10	
La	135	1.E-13	Eu	154	5.E-10	
La	137	1.E-12	Eu	155	9.E-11	
La	138	1.E-10	Eu	156	4.E-10	
La	140	5.E-10	Eu	157	6.E-10	
La	141	4.E-10	Gd	146	3.E-10	
La	142	4.E-10	Gd	147	8.E-11	
Ce	134	2.E-12	Gd	148	<1.E-14	
Ce	135	5.E-10	Gd	149	1.E-10	
Ce	137	2.E-12	Gd	151	3.E-11	
Ce	137 m	4.E-10	Gd	152	<1.E-14	
Ce	139	8.E-11	Gd	153	2.E-11	
Ce	141	4.E-10	Gd	159	5.E-10	
Ce	143	5.E-10	Tb	147	2.E-10	
Ce	144	2.E-10	Tb	149	5.E-12	
Pr	137	2.E-10	Tb	150	2.E-10	
Pr	138 m	1.E-10	Tb	151	2.E-10	
Pr	139	4.E-11	Tb	153	4.E-11	
Pr	142	6.E-10	Tb	154	2.E-10	
Pr	143	4.E-10	Tb	155	3.E-11	
Pr	145	4.E-10	Tb	156	2.E-10	
Nd	138	1.E-12	Tb	156 m	2.E-10	half life: 5 h
Nd	139 m	2.E-10	Tb	156 m	4.E-13	half life: 24 h
Nd	141	1.E-11	Tb	157	9.E-13	
Nd	147	4.E-10	Tb	158	3.E-10	
Nd	149	6.E-10	Tb	160	6.E-10	
Pm	143	8.E-13	Tb	161	4.E-10	
Pm	144	1.E-11	Dy	155	2.E-11	
Pm	145	2.E-11	Dy	157	1.E-11	
Pm	146	2.E-10	Dy	159	2.E-12	
Pm	147	1.E-10	Dy	165	6.E-10	
Pm	148	4.E-10	Dy	166	4.E-10	
Pm	148 m	4.E-10	Ho	161	6.E-12	
Pm	149	4.E-10	Ho	162 m	1.E-10	
Pm	150	6.E-10	Ho	166	8.E-10	
Pm	151	4.E-10	Ho	166 m	3.E-10	
Sm	142	3.E-11	Ho	167	5.E-10	
Sm	145	<1.E-14	Er	161	8.E-11	
Sm	146	<1.E-14	Er	165	8.E-13	
Sm	147	<1.E-14	Er	169	3.E-10	
Sm	151	<1.E-14	Er	171	8.E-10	
Sm	153	7.E-10	Er	172	3.E-10	
Sm	156	5.E-10	Tm	166	2.E-10	
Eu	145	1.E-11	Tm	167	3.E-10	
Eu	146	2.E-11	Tm	170	5.E-10	

Nuclide		$\dot{h}_s$
Tm	171	7.E-13
Tm	172	7.E-10
Tm	173	5.E-10
Yb	166	3.E-11
Yb	169	2.E-10
Yb	175	3.E-10
Yb	177	6.E-10
Yb	178	4.E-10
Lu	169	7.E-11
Lu	170	2.E-10
Lu	171	2.E-11
Lu	172	3.E-10
Lu	173	3.E-11
Lu	174	8.E-11
Lu	174 m	6.E-11
Lu	176	7.E-10
Lu	176 m	6.E-10
Lu	177	4.E-10
Lu	177 m	3.E-10
Lu	179	6.E-10
Hf	170	8.E-11
Hf	172	8.E-11
Hf	173	1.E-10
Hf	175	6.E-11
Hf	178 m	8.E-10
Hf	179 m	4.E-10
Hf	180 m	4.E-10
Hf	181	5.E-10
Hf	182	2.E-10
Hf	182 m	6.E-10
Hf	183	6.E-10
Hf	184	7.E-10
Ta	173	5.E-10
Ta	174	6.E-10
Ta	175	1.E-10
Ta	176	2.E-10
Ta	177	4.E-11
Ta	178	6.E-11
Ta	179	2.E-12
Ta	180	3.E-10
Ta	180 m	1.E-10
Ta	182	5.E-10
Ta	183	7.E-10
Ta	184	7.E-10
W	176	7.E-11
W	177	1.E-10
W	178	1.E-12
W	181	5.E-13
W	185	4.E-10
W	187	5.E-10

Nuclide		$\dot{h}_s$	
W	188	3.E-10	
Re	181	2.E-10	
Re	182	2.E-10	half life: 13 h
Re	182	4.E-10	half life: 64 h
Re	184	1.E-10	
Re	184 m	3.E-10	
Re	186	6.E-10	
Re	186 m	5.E-11	
Re	187	<1.E-14	
Re	188	6.E-10	
Re	189	5.E-10	
Os	181	2.E-10	
Os	182	5.E-11	
Os	185	2.E-11	
Os	189 m	1.E-12	
Os	191	1.E-10	
Os	191 m	1.E-10	
Os	193	6.E-10	
Os	194	4.E-13	
Ir	184	4.E-10	
Ir	185	2.E-10	
Ir	186	2.E-10	half life: 1.8 h
Ir	186	2.E-10	half life: 16 h
Ir	187	5.E-11	
Ir	188	1.E-10	
Ir	189	6.E-11	
Ir	190	3.E-10	
Ir	190 m	2.E-10	hafl life: 3.1 h
Ir	190 m	1.E-12	half life: 1.2 h
Ir	192	5.E-10	
Ir	192 m	3.E-12	
Ir	194	6.E-10	
Ir	194 m	4.E-10	
Ir	195	5.E-10	
Ir	195 m	3.E-10	
Pt	186	2.E-12	
Pt	188	2.E-10	
Pt	189	4.E-11	
Pt	191	8.E-11	
Pt	193	1.E-12	
Pt	193 m	3.E-10	
Pt	195 m	4.E-10	
Pt	197	6.E-10	
Pt	197 m	3.E-10	
Pt	200	6.E-10	
Au	193	1.E-10	
Au	194	4.E-11	
Au	195	4.E-11	
Au	198	5.E-10	
Au	198 m	1.E-09	

Nuclide		$\dot{h}_s$
Au	199	4.E-10
Au	200 m	6.E-10
Hg	185 m	3.E-10
Hg	193	2.E-10
Hg	193 m	2.E-10
Hg	194	2.E-12
Hg	195	5.E-11
Hg	197	1.E-10
Hg	197 m	6.E-10
Hg	203	3.E-10
Tl	195	5.E-11
Tl	197	9.E-11
Tl	198	4.E-11
Tl	198 m	3.E-10
Tl	199	1.E-10
Tl	200	4.E-11
Tl	201	8.E-11
Tl	202	2.E-11
Tl	204	5.E-10
Pb	198	1.E-10
Pb	199	5.E-11
Pb	200	2.E-10
Pb	201	7.E-11
Pb	202	1.E-12
Pb	202 m	2.E-10
Pb	203	9.E-11
Pb	205	1.E-12
Pb	209	5.E-10
Pb	210	1.E-12
Pb	212	5.E-10
Bi	201	3.E-10
Bi	202	1.E-10
Bi	203	1.E-10
Bi	205	2.E-11
Bi	206	2.E-10
Bi	207	7.E-11
Bi	210	6.E-10
Bi	210 m	9.E-11
Bi	212	5.E-10
Po	205	9.E-11
Po	207	6.E-11
Po	210	<1.E-14
At	207	1.E-10
At	211	5.E-12
Rn	222	1.E-14
Ra	223	2.E-10
Ra	224	8.E-12
Ra	225	3.E-10
Ra	226	1.E-11
Ra	228	<1.E-14
Ac	224	6.E-11

Nuclide		$\dot{h}_s$	
Ac	225	4.E-11	
Ac	226	4.E-10	
Ac	227	3.E-13	
Ac	228	5.E-10	
Th	227	6.E-11	
Th	228	5.E-11	
Th	229	2.E-10	
Th	230	2.E-11	
Th	231	3.E-10	
Th	232	7.E-12	
Th	234	7.E-11	
Pa	228	2.E-10	
Pa	230	8.E-11	
Pa	231	2.E-11	
Pa	232	4.E-10	
Pa	233	5.E-10	
Pa	234	1.E-09	
U	230	4.E-11	
U	231	6.E-11	
U	232	2.E-12	
U	233	2.E-12	
U	234	6.E-13	
U	235	6.E-11	
U	236	5.E-13	
U	237	4.E-10	
U	238	5.E-13	
U	240	3.E-10	
Np	234	2.E-11	
Np	235	3.E-13	
Np	236	2.E-10	half life: 23 h
Np	236	5.E-10	half life: 1150 a
Np	237	2.E-11	
Np	238	3.E-10	
Np	239	6.E-10	
Np	240	1.E-09	
Pu	234	4.E-12	
Pu	236	1.E-12	
Pu	237	5.E-12	
Pu	238	1.E-12	
Pu	239	4.E-13	
Pu	240	1.E-12	
Pu	241	<1.E-14	
Pu	242	1.E-12	
Pu	243	4.E-10	
Pu	244	6.E-12	
Pu	245	5.E-10	
Pu	246	2.E-10	
Am	237	1.E-10	
Am	238	2.E-11	
Am	239	4.E-10	
Am	240	8.E-11	

Nuclide		$\dot{h}_s$
Am	241	5.E-12
Am	242	3.E-10
Am	242 m	1.E-12
Am	243	2.E-11
Am	244	8.E-10
Am	245	6.E-10
Cm	238	4.E-12
Cm	240	4.E-13
Cm	241	2.E-10
Cm	242	5.E-13
Cm	243	3.E-10
Cm	244	4.E-13
Cm	245	1.E-10
Cm	246	1.E-12
Cm	247	4.E-11
Cm	248	4.E-10
Cm	249	5.E-10
Cm	250	2.E-09
Bk	245	3.E-10
Bk	246	3.E-11
Bk	247	2.E-10
Bk	249	<1.E-14
Bk	250	5.E-10
Cf	246	7.E-13
Cf	248	1.E-13
Cf	249	7.E-11
Cf	250	3.E-12
Cf	251	5.E-10
Cf	252	1.E-10
Cf	253	2.E-10
Cf	254	5.E-09
Es	250	1.E-11
Es	251	3.E-11
Es	253	8.E-13
Es	254	5.E-12
Es	254 m	5.E-10
Fm	252	2.E-12
Fm	253	3.E-11
Fm	254	2.E-12
Fm	255	1.E-10
Fm	257	2.E-10
Md	257	1.E-11