Radiological Protection Ordinance
(RPO)

of 26 April 2017 (Status as of 1 January 2021)

The Swiss Federal Council,

based on the Radiological Protection Act of 22 March 1991[1] (RPA) and on Article 83 of the Federal Act of 20 March 1981[2] on Accident Insurance,

ordains:

Title 1 General Provisions

Chapter 1 Purpose, Scope and Definitions

Art. 1 Purpose and scope

[1] For the protection of people and the environment against ionising radiation, this Ordinance regulates:

a. for planned exposure situations:
   1. licences,
   2. public exposure,
   3. unjustified activities,
   4. medical exposure,
   5. occupational exposure,
   6. handling of radiation sources,
   7. handling of radioactive waste,
   8. prevention and management of failures;

b. for emergency exposure situations: preparedness and management;

c. for existing exposure situations: management of radiological legacies, radon, naturally occurring radioactive material and long-term contamination following an emergency;

d. training and continuing education of persons handling ionising radiation or radioactivity;

e. supervision and enforcement;

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1 SR **814.50**
2 SR **832.20**

f. advisory activities of the Federal Commission for Radiological Protection (KSR).

[2] It applies to all exposure situations for artificial and for natural ionising radiation.

[3] It does not apply to:

a. exposures to radionuclides naturally present in the human body;

b. exposures to cosmic radiation; it does, however, apply to exposures of aircrew to cosmic radiation;

c. aboveground exposures to radionuclides present in the undisturbed earth's crust.

Art. 2 Definitions

[1] In this Ordinance:

a. *planned exposure situation* means an exposure situation which arises from the planned operation of a radiation source or from a human activity which alters exposure pathways, so as to cause the exposure or potential exposure of people or the environment;

b. *emergency exposure situation* means an exposure situation due to an emergency, as defined in Article 132;

c. *existing exposure situation* means an exposure situation that already exists when a decision on its control has to be taken and which does not call or no longer calls for urgent measures to be taken; this involves, in particular, radiological legacies, radon, naturally occurring radioactive material and long-term contamination following an emergency;

d. *occupational exposure* means exposure due to occupational activities; occupational exposure may involve employees, self-employed persons, apprentices and students;

e. *medical exposure* means the exposure of patients or asymptomatic individuals for diagnostic or therapeutic purposes, with the aim of improving their health, and exposure of carers and comforters in medicine and of participants in human research;

f. *public exposure* means any exposure of persons, excluding occupational and medical exposures;

g. *radiological protection experts* means experts, as specified in Article 16 of the RPA, who have the knowledge, training and experience in radiological protection needed to ensure the effective protection of people and the environment; experts are responsible for implementation of the legal requirements in internal radiological protection directives and for monitoring compliance within the enterprise;

h. *naturally occurring radioactive material (NORM[3])* means material with naturally occurring radionuclides which does not contain artificial radioactive substances; material in which the activity concentrations of naturally occurring radionuclides have been unintentionally changed by some process is also NORM; if concentrations of naturally occurring radionuclides are deliberately enhanced, in particular to utilise their radioactive properties, then they are no longer considered to be NORM;

i. *ionising radiation* means energy transmitted in the form of particles or electromagnetic waves of a wavelength of 100 nm or less capable of ionising an atom or molecule directly or indirectly;

j. *clearance limit (LL)* means the value corresponding to the specific activity level of a material below which handling of this material is no longer subject to mandatory licensing or, accordingly, supervision; the values are specified in Annex 3 Column 9;

k. *NORM clearance limit (LLM)* means the value corresponding to the specific activity level of natural radionuclides in NORM below which this material may be freely discharged into the environment; the values are specified in Annex 2;

l. *licensing limit (LA)* means the value corresponding to the absolute activity level of a material above which handling of this material is subject to mandatory licensing; the values are specified in Annex 3 Column 10; they do not apply to NORM;

m. *guidance value* means a value, derived from a limit, the exceedance of which triggers certain measures and compliance with which also ensures compliance with the associated limit; guidance values for airborne activity (CA) and surface contamination (CS) are specified in Annex 3 Columns 11 and 12;

n. *radiation source* means a radioactive material or installation capable of emitting ionising radiation;

o. *material* is a general term covering solid, liquid or gaseous substances, mixtures, raw materials and finished products and articles manufactured therefrom;

p. *radioactive material* means a material that incorporates radionuclides, is activated or contaminated with radionuclides and which meets the following conditions:

   1. handling thereof is subject to mandatory licensing and supervision under radiological protection or nuclear energy legislation,
   2. handling thereof is not exempt from mandatory licensing and supervision under radiological protection or nuclear energy legislation;

q. *radioactive substance* is synonymous with *radioactive material*;

[3] Footnote relevant to Swiss language texts.

r. *radioactive source* means radioactive material employed for the purpose of utilising its radioactivity;

s. *sealed radioactive source* means a radioactive source whose structure is such as to prevent, under normal conditions of use, the release of radioactive substances and thus exclude the risk of contamination;

t. *unsealed radioactive source* means a radioactive source that does not meet the requirements for a sealed radioactive source;

u. *orphan radioactive material* means radioactive material that is no longer under the control of the owner or licence holder;

v. *installations* is an abbreviated form of *installations that generate ionising radiation*; installations are equipment and devices used to generate photon or particle radiation.

[2] In addition, for this Ordinance, the following apply:

a. the definitions given in Articles 5–7, 26, 49, 51, 80, 85, 96, 108, 122, 149 and 175;

b. the definitions of predominantly technical terms given in Annex 1 and the definitions of dose-related terms given in Annex 4.

Chapter 2 Principles of Radiological Protection

Art. 3 Justification

An activity is justified within the meaning of Article 8 of the Radiological Protection Act (RPA) if:

a. the associated benefits clearly outweigh the radiation-related drawbacks; and

b. overall, for people and the environment, no more favourable alternative is available involving no or lower radiation exposure.

Art. 4 Optimisation

[1] Radiological protection must be optimised for all exposure situations.

[2] Optimisation involves reducing as far as possible and reasonable:

a. the likelihood of exposure;

b. the number of people exposed;

c. the individual dose to the persons exposed.

Art. 5 Dose limits

For planned exposure situations, limits shall be specified which must not be exceeded by the sum of all radiation doses accumulated by a person in a calendar year (dose limit). For medical exposures, no such limits shall be specified.

Art. 6 Reference levels

[1] If in existing exposure situations or in emergency exposure situations the dose limits cannot be complied with, or if in these situations compliance with the dose limits would involve disproportionate efforts or would be counterproductive, then reference levels shall be applied.

[2] To ensure that the reference level can be complied with, the requisite measures must be taken.

Art. 7 Dose constraints

[1] For planned exposure situations, the dose received by a person from a single radiation source or activity shall be specified (dose constraint). This dose constraint shall be specified for each radiation source in such a way that the sum of all doses received from the various radiation sources does not exceed the dose limit.

[2] The licence holder shall specify the dose constraints for the occupationally exposed persons within the enterprise.

[3] The licensing authority (Art. 11) shall decide whether source-related dose constraints are required for the public and shall specify these in the licence. If this has not been done in the case of activities already licensed, the supervisory authority (Art. 184) may specify source-related dose constraints.

[4] Dose constraints are optimisation instruments. When defining dose constraints, the current state of science and technology must be taken into account.

[5] If a dose constraint is exceeded, measures must be taken.

Art. 8 Risk-based graded approach

All radiological protection measures must be graduated according to the underlying risk.

Title 2 Planned Exposure Situations

Chapter 1 Licences

Section 1 Mandatory Licensing

Art. 9 Activities subject to mandatory licensing

In addition to the activities specified in Article 28 of the RPA, or by way of clarification thereof, the following activities are subject to mandatory licensing:

a. the handling of material whose specific activity exceeds the clearance limit and whose absolute activity exceeds the licensing limit;

b. the handling of contained gaseous material whose absolute activity exceeds the licensing limit;

c. the discharge to the environment of material whose specific activity exceeds the clearance limit and whose absolute activity is greater than the activity of 1 kg of a material whose specific activity is equal to the clearance limit;

d. the distribution of material whose specific activity exceeds the clearance limit and whose absolute activity is greater than the activity of 1 kg of a material whose specific activity is equal to the clearance limit;

e. the use of radionuclides in the human body;

f. the deployment of occupationally exposed persons as defined in Article 51 paragraphs 1 and 2 at one's own or at another enterprise in Switzerland or abroad;

g. the performance of quality assurance measures on installations, nuclear medicine imaging equipment and activimeters, or image receptor and display systems used in medical diagnostics;

h. the further use of radiological legacies as specified in Article 150 paragraph 2;

i. activities involving the handling of NORM, if at least one of the situations specified in Article 168 paragraph 2 letters b and c applies;

j.[4] the decay storage of radioactive waste from nuclear installations outside nuclear installations.

Art. 10 Exemptions from mandatory licensing

The following are exempt from mandatory licensing:

a. the transport of radioactive material which does not exceed the activity concentration limits for exempt material or the activity limits for exempt consignments specified in:

1. Annex A, Subsection 2.2.7.2, Tables 2.2.7.2.2.1 and 2.2.7.2.2.2, of the European Agreement of 30 September 1957[5] concerning the International Carriage of Dangerous Goods by Road (ADR), and in the Ordinance of 29 November 2002[6] on the Carriage of Dangerous Goods by Road (SDR), or

4 Inserted by No II of the O of 7 Dec. 2018, in force since 1 Feb. 2019 (AS **2019** 183).
5 SR **0.741.621**. The Annexes to the ADR are not published in the Official Compilation (AS). They can be consulted free of charge on the website of the United Nations Economic Commission for Europe (UNECE) at www.unece.org > Legal Instruments and Recommendations > ADR; offprints can be purchased from the Federal Office for Buildings and Logistics (BBL), Federal Publication Sales, 3003 Bern.
6 SR **741.621**

2. the Regulations concerning the International Carriage of Dangerous Goods by Rail (RID) in accordance with Appendix C, Subsection 2.2.7.2, Tables 2.2.7.2.2.1 and 2.2.7.2.2.2, to the Protocol of 3 June 1999[7] modifying the Convention concerning International Carriage by Rail (COTIF) of 9 May 1980, and in the Ordinance of 31 October 2012[8] on the Carriage of Dangerous Goods by Rail and Cableway (RSD);

b. the transport of radioactive substances as excepted packages:
   1. in accordance with Annex A, Section 3.2.1, Table A (UN numbers 2908, 2909, 2910, 2911 and 3507) of the ADR, and the SDR,
   2. in accordance with Section 3.2.1, Table A (UN Numbers 2908, 2909, 2910, 2911 and 3507) of the RID, and the RSD,
   3. in accordance with Article 16 of the Ordinance of 17 August 2005[9] on Air Transport (LTrV),
   4. in accordance with the Ordinance of 2 March 2010[10] on the Implementation of the European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways;

c. the transport of radioactive substances by air (UN numbers 2908, 2909, 2910, 2911, 2912, 2913, 2915, 2916, 2978, 3321, 3322, 3332 and 3507) in accordance with Annex 18 to the Convention on International Civil Aviation of 7 December 1944[11] and the associated Technical Instructions[12];

7 SR **0.742.403.12**. The Appendices to COTIF are not published in the Official Compilation (AS). The RID can be consulted free of charge on the website of the Intergovernmental Organisation for International Carriage by Rail at www.otif.org > Reference Texts > RID; offprints can be purchased from the Federal Office for Buildings and Logistics (BBL), Federal Publication Sales, 3003 Bern.

8 SR **742.412**

9 SR **748.411**

10 SR **747.224.141**

11 SR **0.748.0**. This Annex is not published either in the Official Compilation (AS). It can be consulted free of charge on the website of the Federal Office of Civil Aviation (FOCA) at www.bazl.admin.ch > Dokumentation > Rechtliche Grundlagen > Internationales Recht, or purchased from the International Civil Aviation Organization (ICAO, Sales Department, 999 Robert-Bourassa Boulevard, Montréal, Quebec H3C 5H7, Canada).

12 The Technical Instructions are not published in the Official Compilation (AS). They can be consulted free of charge on the website of the Federal Office of Civil Aviation (FOCA) at www.bazl.admin.ch > Dokumentation > Rechtliche Grundlagen > Internationales Recht, or purchased from the International Civil Aviation Organization (ICAO, Sales Department, 999 Robert-Bourassa Boulevard, Montréal, Quebec H3C 5H7, Canada). They can also be consulted free of charge, in English and French, at the national airports' information centres. They are not translated into German or Italian.

d. the distribution, use, storage and transport, as well as the import, export and transit, of finished timepieces containing radioactive sources, provided that they comply with the standards ISO[13] 3157[14] and ISO 4168[15], and of no more than 1000 timepiece components with radioactive tritium-based luminous paint;

e. the handling of stray radiation sources, where:
   1. the electron acceleration voltage does not exceed 30 kV, and
   2. the ambient dose rate at a distance of 10 cm from the surface does not exceed 1 µSv per hour[16];

f. the handling of mineral and rock collections with a specific activity below the NORM clearance limits, or if they contain less than 10 g natural thorium or 100 g natural uranium;

g. the handling of radiation sources, with the exception of distribution, for which a type licence has been granted;

h. activities and radiation sources which are subject to mandatory licensing or a decommissioning order under the Nuclear Energy Act of 21 March 2003[17] (NEA);

i. the deployment of occupationally exposed aircrew by aircraft operators.

Section 2 Licensing Procedures

Art. 11 Licensing authorities

[1] Without prejudice to paragraph 2, the Federal Office of Public Health (FOPH) is the licensing authority for all activities and radiation sources subject to mandatory licensing under this Ordinance.

[2] The Swiss Federal Nuclear Safety Inspectorate (ENSI) is the licensing authority for:

a. activities at nuclear installations which are not subject to mandatory licensing or a decommissioning order under the NEA[18];

b. experiments involving radioactive substances in connection with geological investigations as specified in Article 35 of the NEA;

13 International Organization for Standardization. The ISO standards referred to in this Ordinance can be consulted free of charge at the Federal Office of Public Health, CH-3003 Bern. They can be purchased from the Swiss Association for Standardisation, Sulzerallee 70, 8404 Winterthur; www.snv.ch.
14 ISO 3157: 1991-11, Radioluminescence for time measurement instruments – Specifications.
15 ISO 4168: 2003-09, Timekeeping instruments – Conditions for carrying out checks on radioluminescent deposits.
16 Sv = sievert; mSv = millisievert; µSv = microsievert
17 SR **732.1**
18 SR **732.1**

c. the import and export of radioactive substances for or from nuclear installations;

d. the transport of radioactive substances from and to nuclear installations;

e. the discharge of radioactive waste from nuclear installations to the environment;

f.[19] the decay storage of radioactive waste from nuclear installations and all related activities.

Art. 12 Licence applications

[1] Applications for the granting or renewal of a licence must be submitted to the licensing authority with the necessary documents.

[2] In cases of high radiological hazard potential, the licensing authority shall additionally request a hazard analysis.

[3] Applicants from abroad must provide a Swiss postal address.

[4] The Federal Department of Home Affairs (FDHA) and ENSI may issue specifications concerning the documents and evidence required in their area of responsibility.

Art. 13 Standard licensing procedure

[1] Without prejudice to Articles 14 and 15, the licensing authority shall assess activities and radiation sources subject to mandatory licensing using a standard procedure.

[2] It shall review the application documents submitted for completeness, form, content and extent.

[3] It shall decide whether source-related dose constraints are required for the public, and shall specify these in the licence.

Art. 14 Simplified licensing procedure

[1] In cases where the hazard potential for people and the environment is low, the FOPH may assess activities subject to mandatory licensing using a simplified procedure. This concerns in particular:

a. medical applications in the low-dose range (Art. 26 let. a);

b. the operation of installations with full or partial protection systems.

[2] In the simplified procedure, it shall review the application documents submitted solely for completeness and form.

Art. 15 Type licence for radiation sources

[1] In the case of radiation sources with a particularly low hazard potential for people and the environment, the FOPH may grant a type licence (Art. 29 let. c RPA), in particular if:

19 Inserted by No II of the O of 7 Dec. 2018, in force since 1 Feb. 2019 (AS **2019** 183).

a. they are designed or measures are taken so as to prevent inadmissible exposure or contamination of persons; and

b. it is assured that, if necessary, they will be delivered to the federal collection centre as radioactive waste at the end of their useful life.

2 The FOPH shall review the application documents submitted for completeness, form, content and extent.

3 It shall subject the radiation sources for which a type licence is sought to type testing. It may engage other bodies for this purpose.

4 When granting a type licence, it shall specify:

a. under what conditions the radioactive material may be handled;

b. whether and how radioactive material at the end of its useful life must be delivered to the federal collection centre as radioactive waste;

c. whether and how the radiation sources must be marked with a symbol specified by the FOPH.

Art. 16 Licence term and communication

1 The licensing authority shall limit the term of the licence to a maximum of ten years.

2 It shall communicate its decision to the applicant, the cantons concerned and the supervisory authority.

Art. 17 Procedure in the event of uncertainty as to licensing responsibilities

1 If an activity concerns both licensing authorities, the procedures may be combined.

2 The lead authority shall be the one deemed to be primarily concerned on the basis of the application documents.

3 The lead authority shall define the procedure in consultation with the other licensing authority.

Art. 18 Licence database

1 The FOPH shall maintain a database concerning the licences granted under this Ordinance.

2 The purpose of the database is:

a. to make available information required for the granting of licences;

b. to simplify administrative procedures for the granting of licences;

c. to facilitate the supervisory activities of the competent authorities.

3 The following data concerning the licence holder may be stored in the database:

a. for a natural person: name, first name, former name; for a legal person: company name of the legal person;

b. home or business address;

c. for a natural person: function and academic title;

d. telephone numbers;

e. addresses for electronic communication;

f. category of enterprise;

g. the information specified in Article 179 paragraph 3 concerning the radiological protection experts;

h. enterprise identification number (UID) in accordance with the Federal Act of 18 June 2010[20] on the Enterprise Identification Number;

i. Swiss Accident Insurance Fund (Suva) customer number.

4 In addition, technical information on radiation sources may be stored in the database.

5 The following individual access rights apply:

a. The staff of the FOPH Radiological Protection Division, the responsible ENSI unit and Suva Physics are entitled to process the data in the database.

b. Registered licence holders are entitled, via electronic access, to view their licences and the data concerning them stored in the database, and to request amendments.

c. The application managers responsible for maintenance or programming tasks obtain access to data insofar as this is required for the fulfilment of their duties.

Section 3 Duties of Licence Holders

Art. 19 Organisational duties

1 The licence holder must grant the radiological protection expert the powers required to fulfil his or her duties and make available the necessary resources.

2 In addition, the licence holder must:

a. issue internal directives concerning working methods and protective measures and monitor compliance;

b. specify in writing the powers of the various line managers and radiological protection experts, and of persons handling radiation sources.

3 If the licence holder deploys persons from service or other enterprises as occupationally exposed persons, these enterprises must be made aware of the relevant radiological protection regulations.

20 SR **431.03**

Art. 20 Duty to provide information

The licence holder must ensure that all persons within the enterprise who may be exposed to radiation are appropriately informed about the health risks which may arise from handling ionising radiation at the workplace.

Art. 21 Reporting duties

[1] The licence holder must report the following changes to the supervisory authority before they are effected:

a. changes to the output of an installation, structural and design characteristics, and beam direction (Art. 35 para. 1 let. a RPA);

b. a change of the radiological protection expert (Art. 32 para. 2 RPA).

[2] The loss or theft of a radioactive source whose activity exceeds the licensing limit must be reported to the supervisory authority without delay.

Chapter 2 Public Exposure

Art. 22 Dose limits for members of the public

[1] The effective dose must not exceed the limit of 1 mSv per calendar year.

[2] The equivalent dose must not exceed the following limits:

a. for the lens of the eye: 15 mSv per calendar year;

b. for the skin: 50 mSv per calendar year.

Art. 23 Determination of doses in the vicinity of enterprises with a licence for discharge to the environment

[1] In the case of enterprises with a licence for discharge to the environment in accordance with Articles 111–116, the licensing authority may request an annual determination of the dose received by the most exposed members of the public and specify the requirements for the determination of radiation doses.

[2] ENSI shall issue guidelines for the determination of radiation doses for the area under its supervision.

Art. 24 Immission limits

[1] Yearly average airborne activity concentrations in accessible locations off-site must not exceed the immission limits for air (LI_A) specified in Annex 7.

[2] Weekly average activity concentrations in publicly accessible waters must not exceed the immission limits for waters (LI_W) specified in Annex 7.

[3] It must be additionally ensured that ambient doses due to external radiation in dwellings, public-access buildings and workplaces are kept at such a low level that,

taking into account residence time and all other exposure pathways, they cannot lead to exceedance of the dose limits for members of the public.

Chapter 3 Unjustified Activities

Art. 25

The following activities are deemed to be unjustified in accordance with Article 8 of the RPA and are therefore prohibited:

a. the deliberate addition of radionuclides in the production of foodstuffs and feedingstuffs, toys, personal ornaments and cosmetics;

b. the application of methods involving the activation of materials used in toys and personal ornaments;

c. the import, export and transit of products as specified in letters a and b.

Chapter 4 Medical Exposures

Section 1 Dose Ranges in Medical Imaging

Art. 26

Medical exposures are:

a. in the *low-dose range* if the patient receives an effective dose of less than 1 mSv;

b. in the *medium-dose range* if the patient receives an effective dose of between 1 mSv and 5 mSv;

c. in the *high-dose range* if the patient receives an effective dose of more than 5 mSv.

Section 2 Medical Justification

Art. 27 Fundamental justification

Without prejudice to Articles 28 and 29, medical exposures are deemed to be fundamentally justified.

Art. 28 Justification of diagnostic or therapeutic procedures

[1] Any general application of diagnostic or therapeutic procedures must be justified in advance.

2 The justification of existing diagnostic or therapeutic procedures must be reviewed as soon as important new knowledge on the effectiveness or consequences of such procedures becomes available.

3 In collaboration with the professional bodies and sectoral associations concerned, the KSR shall prepare and publish recommendations on the justification of procedures in accordance with paragraphs 1 and 2.[21]

Art. 29 Justification of individual applications

1 Any person who prescribes or performs procedures must take into account existing diagnostic information and the case history in order to avoid unnecessary radiation exposures.

2 Any person who prescribes procedures must establish and document an indication and forward this to the physician performing the procedure.

3 Hospitals, radiology centres and referrers must prescribe procedures in accordance with the current state of science and technology. This is reflected in particular by referral guidelines based on national or international guidelines or recommendations.

4 Each application must be justified in advance by the physician performing the procedure, taking into account the current state of science and technology, the indication and the characteristics of the individual involved.

5 A diagnostic or therapeutic procedure which is not justified in accordance with Article 28 may nonetheless, depending on the circumstances, be justified as a specific, individual application. This must be documented on a case-by-case basis, with the reasons stated, by the physician performing the procedure.

Art. 30 Radiological screening

1 Radiological screening is a radiological examination performed in a specific group of people for the purpose of early detection of a disease, even though it is not clinically suspected in the individuals concerned. This does not include routine occupational health examinations.

2 Radiological screening may only be carried out as part of a programme. It must be instituted by a health authority.

3 Radiological screening must satisfy the quality requirements specified for the programme by the competent health authority.

Art. 31 Procedures for non-medical imaging purposes

1 Activities involving exposure for non-medical imaging purposes must be justified in advance, taking into account the specific objectives of the procedure and the characteristics of the individual involved.

2 Exposures in the medium-dose or high-dose range for aptitude tests are prohibited.

21 www.ksr-cpr.ch

[3] If an exposure is ordered by the criminal investigation, security or customs authorities, the imaging procedure must be performed using the lowest possible dose required to resolve the question. If an exposure cannot be performed in the low-dose range, this must be documented, with the reasons stated.

[4] If exposures are routinely performed for security reasons, the individual examined must be given the option of choosing a different type of examination not involving ionising radiation.

Section 3 Medical Optimisation

Art. 32 Optimisation of medical exposures

[1] In diagnostic, interventional radiology and nuclear medicine examinations, the licence holder must keep all radiation doses as low as achievable consistent with obtaining the required imaging information.

[2] For all therapeutic exposures, the licence holder must carry out individual dosimetric planning. The doses for risk organs must be kept as low as is achievable and consistent with the intended radiotherapeutic purpose.

[3] For the protection of patients, the optimisation process involves in particular:

a. selection of suitable equipment, including software;
b. consistent production of adequate diagnostic information or therapeutic outcomes;
c. the practical aspects of procedures;
d. quality assurance;
e. assessment and evaluation of the patient dose or the administered activity;
f. use of appropriate set-up parameters or appropriate radionuclides;
g. use of sensitive detectors;
h. for every medical installation, use of the elements required for the protection of patients.

[4] The dose received by personnel must be taken into account in the optimisation process.

[5] The FDHA may issue technical optimisation provisions for the protection of patients.

Art. 33 Documentation obligation

The licence holder must document all therapeutic and diagnostic exposures in the medium-dose or high-dose range and in mammography in such a way that the radiation dose received by the patient can be determined at a later date.

Art. 34 Survey of medical population doses

[1] The FOPH shall survey on a regular basis, but at least every ten years, the radiation doses received by the population from medical exposures.

[2] It may request from licence holders anonymised data on therapeutic, diagnostic, interventional or nuclear medicine applications, in particular:

a. time and type of application and anatomical region;

b. exposure parameters;

c. radiation dose or activity levels;

d. installation specifications;

e. sex, age, height and weight of patients;

f. number of individual exposures per application, classified by type and anatomical region.

[3] It may request third parties to prepare statistics. For this purpose, it shall provide them with the necessary data.

Art. 35 Diagnostic reference levels

[1] The FOPH shall publish recommendations on radiation doses for diagnostic, interventional or nuclear medicine examinations in the form of diagnostic reference levels.

[2] To this end, it shall conduct national surveys based on the data specified in Article 34 paragraph 2, take international recommendations into account and publish the results.

[3] Licence holders must regularly review their own practices and account for any deviations from diagnostic reference levels.

Art. 36 Involvement of medical physicists

[1] The licence holder must:

a. closely involve a medical physicist in therapeutic practices, with the exception of standardised nuclear medicine practices;

b. involve a medical physicist in standardised nuclear medicine practices, in computed tomography, in interventional radiology practices and in fluoroscopy in the medium- and high-dose range;

c. if so requested by the supervisory authority, involve a medical physicist in practices of technologically complex examinations or new examination techniques in the low- and medium-dose range.

[2] For therapeutic procedures, the FDHA may specify the level of involvement of medical physicists.

Art. 37 Carers and comforters

[1] The licence holder must ensure that persons helping to comfort and care for patients in a non-professional capacity are informed about their exposure and the associated risks.

[2] For carers and comforters, a dose constraint of 5 mSv per year (effective dose) applies.

[3] If an exceedance of the dose constraint is determined, the licence holder must inform the person concerned.

[4] The FDHA may define specific dose constraints for particular medical procedures.

Section 4 Patients

Art. 38 Provision of information for patients

Patients must be informed about the risks and benefits of medical exposure.

Art. 39 Paediatrics

Medical exposures of children must be performed using exposure parameters specifically optimised for this patient group. In particular, the following must be taken into account:

a. physique;

b. radiosensitivity;

c. the possibility of employing specific technical aids.

Art. 40 Pregnant and breastfeeding patients

[1] For exposures in the medium-dose or high-dose range and for therapeutic exposures in female patients, the physician performing the procedure must establish whether the patient is pregnant.

[2] If pregnancy is determined or cannot be ruled out, this must be weighed against the need for the exposure in the justification. In the optimisation, both the dose to the unborn child and that to the mother must be taken into account.

[3] If the uterus of a pregnant patient lies within the area examined, the dose to the uterus must be documented.

[4] In the case of nuclear medicine exposures, breastfeeding patients must be informed about the need for and duration of a suspension of breastfeeding on account of the contamination of breast milk.

Section 5 Clinical Audits in Medicine

Art. 41 Purpose, content and subjects

[1] The purpose of clinical audits is to ensure that medical exposures are justified and optimised in accordance with the current state of science and technology, and that the quality and outcome of patient care are continuously improved.

[2] Clinical audits involve systematically examining patient- and personnel-related processes for diagnostic and therapeutic procedures involving ionising radiation, and comparing them with the current state of science and technology.

[3] The FOPH may require the licence holder to undergo a clinical audit for the following medical radiation applications every five years:

a. computed tomography;

b. nuclear medicine;

c. radiation oncology;

d. fluoroscopy-guided interventional diagnostic and therapeutic procedures.

Art. 42 Coordination, preparation and conduct

[1] If the FOPH engages third parties for the coordination and preparation of clinical audits (Art. 189), they must be experts from various institutions and professional bodies.

[2] If the FOPH engages third parties for the conduct of clinical audits (Art. 189), these auditors must have many years' professional experience in their field and must be independent of the audited licence holders.

[3] The FOPH shall make the necessary data concerning licence holders available to the third parties engaged.

[4] If, in the evaluation of audits, the third parties engaged discover significant deviations from the requirements of this Ordinance or from the current state of science and technology, they shall inform the FOPH.

Art. 43 Licence holders' self-evaluation and quality manual

[1] All holders of licences for radiation applications as specified in Article 41 paragraph 3 shall conduct an annual self-evaluation of their processes.

[2] They shall prepare a quality manual and present this at the audit.

[3] The quality manual must include a detailed description of at least the following points:

a. competences and responsibilities;

b. equipment available for examination and treatment;

c. personnel training;

d. measures to ensure compliance with requirements concerning the justification of individual applications (Art. 29);

e. examination and treatment protocols and patient information;

f. documentation of radiation doses (Art. 33);

g. establishment and communication of diagnostic findings or treatment monitoring, data storage and data transfer;

h. quality assurance;

i. self-evaluation.

Section 6 Research involving Human Beings

Art. 44 Authorisations

[1] The conduct of human research projects involving the use of radiation sources requires authorisation in accordance with Article 45 of the Human Research Act of 30 September 2011[22] (HRA).

[2] In addition, the conduct of clinical trials of therapeutic products capable of emitting ionising radiation requires authorisation in accordance with Article 54 of the Therapeutic Products Act of 15 December 2000[23] (TPA).

Art. 45 Dose constraints and dose calculation

[1] In research projects with no expected direct benefit, a dose constraint of 5 mSv per year (effective dose) applies to the participants.

[2] In exceptional cases, the dose constraint specified in paragraph 1 may be up to 20 mSv per year (effective dose), with consideration being given to age, fertility, life expectancy and health status, provided that this is absolutely essential for methodological reasons.

[3] In the case of combined procedures, all radiation sources must be taken into account in the calculation or estimation of the dose to participants.

[4] In the calculation or estimation of the dose, the uncertainty factor must be taken into account.

Section 7 Radiopharmaceuticals

Art. 46 Placing products on the market and administration

[1] For the placing of products on the market and administration of radiopharmaceuticals in humans, the provisions of the TPA[24] apply.

22 SR **810.30**
23 SR **812.21**

[2] Approval is required from the FOPH for:

a. the marketing authorisation of radiopharmaceuticals in accordance with Article 9 paragraph 1 of the TPA;

b. the simplified authorisation of radiopharmaceuticals in accordance with Article 14 of the TPA;

c. the authorisation of radiopharmaceuticals for a limited period in accordance with Article 9 paragraph 4 of the TPA.

[3] The FOPH shall grant approval based on the documents received as part of the application for authorisation, and on the assessment and reasoning of the Expert Commission for Radiopharmaceuticals.

[4] Radiopharmaceuticals must be labelled as such. Their package labelling must include at least the following radiological protection-related information:

a. the preparation name;

b. the hazard warning symbol in accordance with Annex 8;

c. the radionuclides and their activity at the time of calibration;

d. the calibration time and the expiry time.

[5] For the labelling, the provisions of the medicinal products legislation also apply.

[6] Long-lived radionuclide impurities relevant to disposal must be indicated in the accompanying documents.

Art. 47 Preparation and quality control

[1] Any person who prepares radiopharmaceuticals must carry out the quality controls described in the product information.

[2] The FOPH may take samples at any time in order to determine whether the requirements specified in Article 46 are still being met. For this purpose, it may engage specialised laboratories.

[3] The FDHA may specify requirements for the preparation and use of radiopharmaceuticals; it shall take into account national and international guidelines and the recommendations of professional bodies, in particular those issued by the European Association of Nuclear Medicine (EANM)[25] or the Swiss Society of Radiopharmacy/Radiopharmaceutical Chemistry (SGRRC)[26].

24 SR **812.21**

25 These guidelines (in English) can be accessed free of charge on the EANM website at www.eanm.org.

26 These recommendations can be accessed free of charge on the SGRRC website at www.sgrrc.ch.

Art. 48 Expert Commission for Radiopharmaceuticals

[1] The Expert Commission for Radiopharmaceuticals (ECRP) is a standing advisory commission within the meaning of Article 8a paragraph 2 of the Government and Administration Organisation Ordinance of 25 November 1998[27] (GAOO).

[2] It shall advise the Federal Department of Home Affairs (FDHA), Swissmedic and the FOPH on radiopharmaceutical matters. In particular, it has the following tasks:

a. it prepares reports on applications for the marketing authorisation of radiopharmaceuticals;

b. it prepares reports on safety-related questions connected with radiopharmaceuticals;

c. it advises the FHHA on the amendment of Annex 1 to the Therapeutic Products Ordinance of 21 September 2018[28].[29]

It is comprises specialists from the fields of nuclear medicine, pharmaceutics, chemistry and radiological protection.

Section 8 Medical Radiation Incident

Art. 49 Definition

A medical radiation incident is an unplanned event in the form of a careless or inappropriate action, with or without actual consequences, which, as a result of deficiencies in the quality assurance programme, technical malfunctions, operator error or other incorrect behaviour, led or could have led to unintended exposures of patients.

Art. 50 Duties

[1] Licence holders must keep a record of medical radiation incidents.

[2] They must, with an interdisciplinary working group, regularly analyse any incidents which have occurred and make the operational adjustments required to prevent similar incidents.

[3] They must report the following medical radiation incidents to the supervisory authority within 30 days:

a. unplanned exposures which led or could have led to moderate organ damage, moderate functional impairment or more serious damage in the patient;

b. confusion of patients or organs in therapeutic exposures or in diagnostic exposures in the high-dose range;

27 SR **172.010.1**
28 SR **821.212.21**
29 Amended by Annex 6 No II 4 of the Therapeutic Products Ordinance of 21 Sept. 2018, in force since 1 Jan. 2019 (AS **2018** 3577).

c. unplanned exposures where the patient received an effective dose of more than 100 mSv.

4 In the case of medical radiation incidents as specified in paragraph 3, the licence holder must conduct an investigation and submit a report in accordance with Article 129.

Chapter 5 Occupational Exposures

Section 1 Occupationally Exposed Persons

Art. 51 Definition and principles

1 Occupationally exposed persons means persons who:

a. in the course of their occupational activities or training may incur exposure which exceeds a dose limit for members of the public as specified in Article 22; this is without prejudice to paragraph 2;

b. work or undergo training at least once a week in controlled areas as defined in Article 80; or

c. work or undergo training at least once a week in supervised areas as defined in Article 85 and may thus be exposed to an increased ambient dose rate.

2 Persons who are subject solely to radon exposure at their workplace are only deemed to be occupationally exposed if they may thereby accumulate an effective dose of more than 10 mSv per year (Art. 167 para. 3).

3 The licence holder, or in the case of aircrew the aircraft operator, shall designate all occupationally exposed persons within the enterprise.

4 Licence holders, or in the case of aircrew the aircraft operator, shall inform the occupationally exposed persons regularly of:

a. the radiation doses to be expected in the course of their work;

b. the dose limits applicable for them;

c. the health risks associated with their work;

d. the radiological protection measures which must be observed for their work;

e. the risks of radiation exposure for the unborn child.

Art. 52 Categories

1 For purposes of monitoring, licence holders shall classify the occupationally exposed persons into categories A and B in accordance with paragraphs 2–4.

2 Category A comprises persons who:

a. may accumulate the following doses per calendar year in the course of their work:

1. an effective dose greater than 6 mSv,

2. an equivalent dose for the lens of the eye greater than 15 mSv, or
3. an equivalent dose for the skin, hands or feet greater than 150 mSv;

b. as a result of radon exposure at the workplace receive an effective dose greater than 10 mSv per calendar year; or

c. work as internal personnel at a nuclear installation.

3 Category B comprises all occupationally exposed persons not belonging to category A.

4 Persons engaged in activities where the risk of accumulating doses as specified in paragraph 2 letter a is negligible shall be assigned to category B for the performance of these activities. This includes in particular activities:

a. involving the operation of diagnostic X-ray systems in medical, dental and veterinary practices, except in the high-dose range;

b. as occupationally exposed aircrew.

5 If applicants or licence holders demonstrate that an activity does not fulfil any of the conditions specified in paragraph 2, they may request the supervisory authority to assign the persons performing this activity to category B.

Art. 53 Young people and pregnant or breastfeeding women

1 Persons aged under 16 years must not be occupationally exposed.

2 For persons aged between 16 and 18 years and for pregnant women, the dose limits specified in Article 57 apply.

3 From the time when a pregnancy becomes known until its completion, the radiation exposure of the pregnant woman must be determined monthly.

4 The FDHA shall specify, in consultation with ENSI, when pregnant women must be additionally equipped with an active personal dosimeter.

5 Pregnant women must, if they so request, be exempted from the following activities:

a. from flight duties;

b. from any work with radioactive material involving a risk of intakes or contamination;

c. from activities which may only be performed by an occupationally exposed person in category A.

6 Breastfeeding women must not perform any work with radioactive material involving an increased risk of intakes.

Art. 54 Aircrew

For occupationally exposed aircrew, radiation exposure must be optimised when establishing work plans.

Art. 55 Medical monitoring

[1] The licence holder must have medical assessments conducted in accordance with Article 11*a* of the Ordinance of 19 December 1983[30] on Accident Prevention (APO).

[2] Suva may subject employees to the preventive occupational medicine provisions specified in Articles 70–89 APO.

Section 2 Dose Restrictions

Art. 56 Dose limits

[1] For occupationally exposed persons, the effective dose must not exceed the limit of 20 mSv per calendar year.

[2] For such persons, by way of exception and with the approval of the supervisory authority, the limit for the effective dose may be up to 50 mSv per calendar year, provided that the cumulative dose over five consecutive years, including the current year, is less than 100 mSv.

[3] For such persons, the equivalent dose must not exceed the following limits:

a. for the lens of the eye: 20 mSv per calendar year or a cumulative dose of 100 mSv over five consecutive calendar years, subject to a maximum dose of 50 mSv in a single calendar year;

b. for the skin, hands and feet: 500 mSv per calendar year.

[4] Occupationally exposed persons from abroad must, in Switzerland, only accumulate an effective dose of 20 mSv per calendar year, allowing for the dose already received in the current calendar year.

Art. 57 Dose limit for young people and pregnant women

[1] For persons aged 16–18 years, the effective dose must not exceed the limit of 6 mSv per calendar year.

[2] Pregnant women may only be deployed as occupationally exposed persons if it is assured that, from the time when a pregnancy becomes known until its completion, the effective dose to the unborn child does not exceed 1 mSv.

Art. 58 Measures to be taken if dose limits are exceeded

[1] If a dose limit as specified in Article 56 paragraphs 1–3 and Article 57 paragraph 1 is exceeded in an occupationally exposed person, then, for the rest of the calendar year, the person concerned may accumulate no more than:

a. an effective dose of 1 mSv;

b. an equivalent dose of 15 mSv for the lens of the eye, and of 50 mSv for the skin, hands and feet.

30 SR **832.30**

[2] The right of the supervisory authority to grant approval in accordance with Article 56 paragraph 2 is reserved.

[3] If the dose limit specified in Article 57 paragraph 2 is exceeded, the women concerned must not, for the remainder of their pregnancy, be deployed in controlled or supervised areas as defined in Articles 80 and 85.

Art. 59 Medical surveillance in the event of exceedance of dose limits

[1] If a dose limit specified in Article 56 or 57 is exceeded, the supervisory authority shall decide whether the person concerned must be placed under medical surveillance.

[2] The physician shall inform the person concerned and the supervisory authority of the results of his or her investigation and propose measures to be adopted. If the person concerned is an employee, the physician shall also inform Suva.

[3] The physician shall report to the supervisory authority:

a. data concerning any early effects detected;

b. data concerning illnesses or special predispositions making it necessary to declare the person unfit for radiation work;

c. biological dosimetry data.

[4] If the person concerned is an employee, the physician shall also report the data to Suva.

[5] Suva, or the supervisory authority in the case of persons not in employment, shall take the necessary measures. It may order a temporary or permanent exclusion from activities involving occupational exposure.

Art. 60 Dose constraints

[1] For the purpose of optimising radiological protection, the licence holder, or in the case of aircrew the aircraft operator, shall specify dose constraints for occupationally exposed persons.

[2] The principle of optimisation is deemed to be satisfied where activities do not lead to an effective dose of more than 100 µSv per calendar year for occupationally exposed persons.

[3] If a dose constraint is exceeded, the working practice must be reviewed and radiological protection improved.

Section 3 Determination of Radiation Doses (Dosimetry)

Art. 61 Dosimetry in occupationally exposed persons

[1] In occupationally exposed persons, radiation exposure must be determined individually in accordance with Annex 4 (individual monitoring).

[2] External exposure must be determined every month.

3 The supervisory authority may grant exemptions from paragraphs 1 and 2 if:

a. an additional or another appropriate dose monitoring system is available;

b. no appropriate dose monitoring system is available, but enhanced radiological protection measures are taken.

4 The FDHA shall specify, in consultation with ENSI, how and at what intervals internal radiation exposure is to be determined. In doing so, it shall take into account the working conditions and the type of radionuclides used.

5 It shall specify, in consultation with ENSI, when a second, independent dosimetry system fulfilling an additional function must be used.

Art. 62 Determination of radiation doses by calculation

1 In cases where individual dose measurement is not suitable, the licence holder must determine the radiation dose by calculation; this requires the approval of the supervisory authority.

2 The FDHA, in consultation with ENSI, shall issue provisions concerning the determination of radiation doses by calculation.

3 In the case of aircrew, aircraft operators may themselves determine radiation doses by calculation. The software used for this purpose must reflect the state of the art.

Art. 63 Reporting threshold per monitoring period

1 For occupationally exposed persons at enterprises licensed by the FOPH, the following reporting thresholds per dosimetric monitoring period apply:

a. 2 mSv for the effective dose;

b. 2 mSv for the equivalent dose for the lens of the eye;

c. 50 mSv for the equivalent dose for the skin, hands or feet.

2 When a reporting threshold is reached, the reporting duties specified in Article 65 paragraph 1 letter c and Article 69 letter b arise.

Art. 64 Duties of licence holders or aircraft operators with regard to personal dosimetry

1 Licence holders, or, in the case of aircrew, aircraft operators, must have the radiation exposure of all occupationally exposed persons within the enterprise determined by an approved personal dosimetry service. They may also themselves determine doses by calculation as specified in Article 62 or carry out triage measurements to detect internal radiation exposure.

2 They shall bear the costs of dosimetry.

3 They must:

a. inform the persons concerned of the results of dosimetry;

b. furnish them with a written summary of all doses:

1. upon termination of employment,
2. prior to deployment at another enterprise;

c. provide Suva with the operational, personal and dosimetry data required for preventive occupational medicine;

d. when a reporting threshold as specified in Article 63 is reached, provide the supervisory authority, if so requested, with an explanation of the cause of the dose; the explanation must be provided in writing within two weeks;

e. communicate to the appointed personal dosimetry service the data specified in Article 73 paragraph 1 letters a–e and g–i for all occupationally exposed persons within the enterprise;

f. report directly to the Central Dose Registry doses accumulated by occupationally exposed persons working abroad which were not determined by a Swiss personal dosimetry service; the report must be submitted within a month after the end of the assignment in a form prescribed by the FOPH.

Art. 65 Duties of licence holders or aircraft operators when radiation doses are determined by calculation

[1] If radiation doses are determined by calculation within the enterprise as specified in Article 62, licence holders, or, in the case of aircrew, aircraft operators, must report:

a. the data specified in Article 73: to the Central Dose Registry (Art. 72);

b. the radiation doses determined by calculation: to the Central Dose Registry within a period specified by the FOPH in a form prescribed by the FOPH;

c. the reaching of a reporting threshold as specified in Article 63: to the supervisory authority no later than ten days after the radiation dose has been calculated;

d. a suspected exceedance of a dose limit: within one working day, to the supervisory authority and, if the person concerned is an employee, to Suva.

[2] For enterprises within the area supervised by ENSI, this authority shall issue additional guidelines concerning the reporting of radiation doses determined by calculation.

Section 4 Personal Dosimetry Services

Art. 66 Requirements for approval

[1] A personal dosimetry service must be approved by the competent authority (Art. 68).

[2] It shall be approved if the following requirements are met:

a. It is domiciled in Switzerland.

b. It has an appropriate organisation and sufficient staff, in particular an adequate number of persons with a practical knowledge of the relevant measurement technique and of radiological protection.

c. It demonstrates to the competent authority that it has, and implements, a quality assurance programme.

d. The measurement system reflects the state of the art and can be related to appropriate standards through an unbroken chain of comparisons.

3 If a personal dosimetry service is accredited for personal dosimetry, the requirements specified in paragraph 2 letters c and d are deemed to be met.

Art. 67 Approval procedure and term

1 The competent authority shall determine, by means of an inspection and a technical review, whether a personal dosimetry service meets the requirements for approval. It may engage third parties for this purpose.

2 Approval may be granted for a maximum of five years.

Art. 68 Competent authorities

1 The following authorities are responsible for approval:

a. the FOPH, in cases where a personal dosimetry service wishes to operate wholly or largely within the area supervised by the FOPH or by Suva;

b. ENSI, in cases where a personal dosimetry service wishes to operate wholly or largely within the area supervised by this authority

2 In cases where a personal dosimetry service wishes to operate in various areas, the competent authorities shall jointly decide which of them is to be responsible for approval.

3 The competent authorities must not operate any personal dosimetry services themselves.

Art. 69 Reporting duties of the personal dosimetry service

The personal dosimetry service has the following reporting duties:

a. Within a month after the end of the monitoring period, it shall report the data specified in Article 73 to the following:
   1. the licence holder or, in the case of aircrew, the aircraft operator;
   2. the Central Dose Registry (Art. 72), in a form prescribed by the FOPH;
   3. in the case of data from the area supervised by ENSI: also directly to ENSI.

b. If a reporting threshold per monitoring period as specified in Article 63 is reached, the personal dosimetry service shall notify the licence holder and the supervisory authority no later than ten working days after receipt of the dosimeter.

c. In the event of a suspected exceedance of a dose limit, the personal dosimetry service shall report the result to the licence holder, or, in the case of aircrew, to the aircraft operator, and to the supervisory authority within one working day. If the person concerned is an employee, it shall also inform Suva.

d. For personal dosimetry services approved by ENSI, this authority shall issue reporting guidelines.

Art. 70 Further duties of the personal dosimetry service

1 The personal dosimetry service must retain the dose values and personal details, as well as all the raw data required for calculation of the doses to be reported at a later date, for a period of two years after submission to the Central Dose Registry.

2 In accordance with the instructions of the competent authority, it must participate at its own expense in intercomparison exercises.

3 If a personal dosimetry service wishes to cease its activities, it must give the competent authority, its clients and the supervisory authorities responsible for its clients at least six months' advance notice.

4 The personal dosimetry service ceasing its activities shall transfer its archived data to the new personal dosimetry services designated by its clients.

5 In exceptional cases, the competent authority shall determine the steps to be taken.

6 If a client terminates its contractual relationship with the personal dosimetry service, the latter must draw the client's attention to its duties as a licence holder as specified in Article 64 and inform the supervisory authority of the termination.

Art. 71 Duty of confidentiality and data protection

The personal dosimetry service may only disclose personal details and the results of dosimetry:

a. to the individual concerned;

b. to the licence holder or, in the case of aircrew, the aircraft operator;

c. to the supervisory authority;

d. to the licensing authority;

e. to the Central Dose Registry.

Section 5 Central Dose Registry

Art. 72 Responsible authority and purpose

1 The FOPH shall maintain a Central Dose Registry.

2 The purpose of the Registry is to record the doses determined throughout the period during which a person is occupationally exposed, in order to assess possible insurance claims on this basis.

3 In addition, the Registry enables the supervisory authorities:

a. to review at any time the doses accumulated per monitoring period for each occupationally exposed person in Switzerland;

b. to conduct statistical analyses and evaluate the effectiveness of the provisions of this Ordinance;

c. to ensure data retention.

Art. 73 Data processed

1 The following data concerning occupationally exposed persons shall be stored in the Central Dose Registry:

a. name, first name and former names;

b. date of birth;

c. insurance number as specified in Article 50*c* of the Federal Act of 20 December 1946[31] on the Old-Age and Survivors' Insurance;

d. sex;

e. name, address and UID of the enterprise;

f. dose values determined in Switzerland and abroad;

g. occupational group;

h. activity;

i. category (A or B).

2 For persons working in Switzerland only temporarily, the doses determined in Switzerland shall be recorded.

Art. 74 Access rights

The following shall have direct electronic access to data in the Central Dose Registry:

a. the staff of the FOPH Radiological Protection Division;

b. the Suva Occupational Medicine Department;

c. the supervisory authorities: the data in the area under their supervision;

d. the Federal Office of Civil Aviation (FOCA): the data concerning aircrew.

31 SR **831.10**

Art. 75 Reporting

[1] The supervisory authorities shall produce annual reports on the results of personal dosimetry.

[2] The reports shall be published by the FOPH. It shall ensure that the persons concerned are not identifiable.

Art. 76 Use of data for research projects

[1] The FOPH may use, or make available to third parties on request, the personal data stored in the Central Dose Registry for research projects concerning the effects of radiation and radiological protection. The provisions of the HRA[32] are applicable.

[2] The FOPH shall only make the personal data available in an anonymised form, unless the applicant demonstrates that:

a. the persons concerned have consented to the disclosure of their data; or

b. the applicant has been granted authorisation by the responsible ethics committee in accordance with Article 45 of the HRA.

Section 6 Technical Provisions for Personal Dosimetry

Art. 77

[1] The FDHA, in consultation with ENSI and after a hearing with the Federal Institute of Metrology (METAS), shall issue technical provisions for personal dosimetry.

[2] The technical provisions shall specify in particular:

a. minimum requirements for measurement systems;

b. minimum requirements for measurement accuracy in routine operations and for intercomparison exercises;

c. standard models for calculation of radiation doses.

Chapter 6 Radioactive Material and Installations

Section 1 Controlled and Supervised Areas

Art. 78 Principles

[1] In order to limit and monitor radiation exposure, the licence holder shall establish controlled or supervised areas.

[2] Activities involving radioactive material above the licensing limit, with the exception of sealed radioactive sources, must be carried out within controlled areas in rooms which are designed as working areas as specified in Article 81.

32 SR **810.30**

[3] For rooms and locations within supervised or controlled areas where contamination of surfaces or indoor air or increased ambient dose rates may occur, the supervisory authority may order a classification into zones as specified in Article 82 and dispense with the establishment of working areas.

Art. 79 Restriction of ambient doses

[1] The room or area in which installations are operated or radioactive material is handled must be designed or shielded in such a way that no limits are exceeded.

[2] At locations outside of controlled and supervised areas where members of the public may be continuously present, the weekly ambient dose must not exceed 0.02 mSv. At locations where people are not continuously present, this value may be exceeded by up to a factor of five.

[3] If the locations specified in paragraph 2 are workplaces, the ambient dose, given an assumed work-related presence of 40 hours per week, may be higher.

[4] The influence of several different radiation sources on a location to be protected must be taken into account.

[5] The FDHA, in consultation with ENSI, shall specify guidance values for the ambient dose within and outside of controlled and supervised areas.

Section 2 Controlled Areas

Art. 80 Definition

[1] *Controlled areas* means areas which are subject to specific requirements for the purpose of protecting against exposures to ionising radiation and preventing the spread of contamination. In the area supervised by ENSI, the term *controlled zone* may continue to be used for controlled areas.

[2] The following are to be established as controlled areas:

a. working areas as specified in Article 81;

b. zone types I–IV as specified in Annex 10;

c. areas in which airborne contamination may exceed 0.05 CA as specified in Annex 3 Column 11 or surface contamination may exceed 1 CS as specified in Annex 3 Column 12.

[3] The supervisory authority may request that further areas be established as controlled areas if this is appropriate for organisational reasons.

[4] The licence holder must ensure that access to controlled areas is only possible for authorised persons.

[5] Controlled areas must be clearly delimited and marked as specified in Annex 8.

[6] The licence holder must supervise compliance with guidance values for ambient dose rates, contamination and indoor air activity concentrations, and compliance with protection measures and safety provisions within controlled areas.

Art. 81 Working areas

[1] Working areas must be established within a controlled area in separate rooms reserved for these purposes.

[2] They shall be classified into the following types, according to the activity of the radioactive materials handled per operation or per day:

a. type C: an activity from 1 to 100 times the licensing limit;

b. type B: an activity from 1 to 10 000 times the licensing limit;

c. type A: an activity from 1 times the licensing limit to an upper limit defined in the licensing procedure.

[3] For the storage of radioactive materials in working areas, the supervisory authority may increase the values specified in paragraph 2 by up to a factor of 100.

[4] The supervisory authority may allow exceptions to paragraph 1 on operational grounds, provided that radiological protection is assured.

[5] The supervisory authority may in exceptional cases, where handling involves a low risk of intakes, increase the values specified in paragraph 2 by up to a factor of 10, provided that radiological protection is assured.

[6] The supervisory authority may in individual cases, taking into account the risk of intakes, assign working areas to a different type from that specified in paragraph 2, provided that only activities involving a low risk of inhalation are carried out therein.

[7] The FDHA, in consultation with ENSI, shall issue the necessary regulations concerning protection measures.

Art. 82 Zones

[1] Zones shall be classified into the zone types specified in Annex 10 according to the degree of contamination present or to be expected.

[2] For the purpose of planning and regulation of individual doses, within zones with elevated ambient dose rates, areas with maximum permissible ambient dose rates must be established and designated as specified in Annex 10.

[3] The supervisory authority may in exceptional cases approve other zone and area types if radiological protection is equally well or better assured.

[4] The FDHA, in consultation with ENSI, shall issue regulations concerning protection measures for the various zone and area types.

Art. 83 Treatment after discontinuation of activities

[1] For controlled areas in which the handling of radioactive material is discontinued, and if necessary also for the surrounding areas, including all installations and the remaining material, the licence holder must ensure that the clearance measurement criteria specified in Article 106 are met and the immission limits specified in Article 24 are not exceeded.

2 The licence holder must demonstrate to the supervisory authority that the duty specified in paragraph 1 is fulfilled.

3 The licence holder may only use the controlled areas concerned for other purposes after approval has been granted by the supervisory authority.

Art. 84 Guidance values for contamination

1 Before persons leave, or materials are removed from, controlled areas, it must be ensured that the guidance value specified in Annex 3 Column 12 for surface contamination is not exceeded. For the clearance of materials, the requirements specified in Article 106 apply.

2 If, in controlled areas, the contamination of materials and surfaces is greater than 10 times the guidance value specified in Annex 3 Column 12, decontamination measures must be implemented or other appropriate protection measures adopted.

3 If, in controlled areas, part of the contamination will remain attached to the surface under foreseeable conditions of handling, the guidance values specified in Annex 3 Column 12 shall only apply to the transferable contamination.

Section 3 Supervised Areas

Art. 85

1 *Supervised areas* means areas which are subject to specific requirements for the purpose of protecting against exposures to ionising radiation from the operation of installations or the handling of sealed radioactive sources.

2 The following are to be established as supervised areas:

a. rooms and adjacent areas in which installations are operated without a full or partial protection system;

b. zones of type 0 as specified in Annex 10;

c. areas in which persons may accumulate an effective dose of more than 1 mSv per calendar year from external radiation exposure.

3 The licence holder must ensure that, if elevated ambient dose rates occur during the operation of installations or the handling of sealed radioactive sources, only authorised persons can be present in supervised areas.

4 The licence holder must monitor compliance with the guidance values for ambient dose rates and compliance with protection measures and safety provisions within supervised areas.

5 Supervised areas must be marked as specified in Annex 8.

6 The establishment of supervised areas is not necessary for occupationally exposed aircrew.

7 In rooms in which only compact dental X-ray systems are operated, the establishment of supervised areas is not necessary.

Section 4 Duties when handling Radiation Sources

Art. 86 Inventory, record-keeping and reporting duties

[1] When handling sealed radioactive sources, licence holders must maintain an inventory.

[2] They must keep records of the purchase, use, transfer and disposal of radioactive materials.

[3] They must report annually to the supervisory authority on their trade in radiation sources, providing the following information:

a. the name of the radionuclides, their activity, the date of activity determination, and their chemical and physical form;

b. the name of the equipment or articles containing radioactive sources, with details of the radionuclides, their activity and the date of activity determination;

c. the name of the installations and the associated parameters;

d. the addresses and licence numbers of domestic clients.

[4] The licensing authority may specify additional record-keeping and reporting duties in the licence.

Art. 87 Transfer

Holders of radiation sources subject to mandatory licensing may only supply them to enterprises or persons holding the requisite licence.

Art. 88 Requirements for the handling and the location of radiation sources

The EDI, in consultation with ENSI, shall define the requirements for the handling and the location of radiation sources. In particular, it shall specify:

a. structural measures and the basis for calculations in this regard;

b. the requirements for irradiation, administration and relaxation rooms, and for rooms for equipment used for nuclear medicine examinations;

c. the radiological protection measures for the care and accommodation of patients receiving therapy;

d. the type of storage and the requirements for facilities for the storage of radioactive materials.

Section 5 Measuring Instruments

Art. 89 Measuring instruments for ionising radiation

[1] Licence holders must ensure that the enterprise has the necessary number of suitable measuring instruments for ionising radiation.

[2] In rooms or areas where radiation sources are handled or operated and a related hazard exists, suitable measuring instruments for ionising radiation must be available at all times to monitor dose rates and surface or airborne contamination.

Art. 90 Requirements for measuring instruments for ionising radiation

Measuring instruments for ionising radiation are governed by the Measuring Instruments Ordinance of 15 February 2006[33] and the implementing provisions issued by the Federal Department of Justice and Police (FDJP) in consultation with the FDHA and the Federal Department of the Environment, Transport, Energy and Communications (DETEC).

Art. 91 Requirements for the use of measuring instruments for ionising radiation

The FDHA, in consultation with ENSI, shall specify:

a. the type and the number of instruments required for measuring ionising radiation;

b. the extent of quality assurance for the use of measuring instruments for ionising radiation.

Art. 92 Duties of licence holders

[1] Licence holders must carry out functional testing of measuring instruments for ionising radiation at appropriate intervals, using suitable radiation sources.

[2] The supervisory authority may require licence holders to participate in intercomparison exercises.

Section 6 Design and Marking of Sealed Radioactive Sources

Art. 93 Design

[1] With regard to design, sealed radioactive sources must reflect the state of the art when they are placed on the market.

[2] For sealed radioactive sources, the radionuclides selected must be chemically as stable as possible.

33 SR **941.210**

3 If sealed radioactive sources are used exclusively as gamma or neutron emitters, shielding must be provided which prevents the escape of alpha or beta radiation.

Art. 94 Marking

1 Sealed radioactive sources and their containers must be marked in such a way as to permit identification of the source at any time.

2 The manufacturer or supplier of a high-activity sealed source as defined in Article 96 must ensure that it can be identified by a unique number. This number must be engraved or stamped on the source and on the source container.

3 The radionuclide, activity, date of manufacture and measurement, and if appropriate the classification according to ISO 2919[34], must be immediately apparent or ascertainable from the marking.

4 The supervisory authority may grant exemptions from paragraphs 1–3 if marking is not practicable or if reusable source containers are used.

Art. 95 Further requirements for placing on the market

1 Before being placed on the market, every sealed radioactive source must be tested for leak tightness and absence of contamination. Testing must be carried out by a body accredited for this activity or recognised by the supervisory authority.

2 The capsule of sealed radioactive sources whose activity is greater than 100 times the licensing limit must comply with the requirements of ISO 2919[35] for the intended application and be classified accordingly.

3 In justified cases, the supervisory authority may grant exemptions from paragraphs 1 and 2 or require additional quality tests.

Section 7 High-Activity Sealed Sources

Art. 96 Definition

High-activity sealed source means a sealed radioactive source whose activity is greater than the activity value specified in Annex 9.

34 ISO 2919: 2012-02-15, Radiological protection – Sealed radioactive sources – General requirements and classification. The ISO standards referred to in this Ordinance can be consulted free of charge at the Federal Office of Public Health, CH 3003 Bern. They can be purchased from the Swiss Association for Standardisation, Sulzerallee 70, 8404 Winterthur; www.snv.ch.

35 ISO 2919: 2012-02-15, Radiological protection – Sealed radioactive sources – General requirements and classification. The ISO standards referred to in this Ordinance can be consulted free of charge at the Federal Office of Public Health, CH 3003 Bern. They can be purchased from the Swiss Association for Standardisation, Sulzerallee 70, 8404 Winterthur; www.snv.ch.

Art. 97 Inventory

[1] The licensing authority shall maintain an inventory of licence holders and of the high-activity sealed sources in their possession.

[2] The inventory shall include:

a. the identification number;

b. the supplier;

c. the type and location of the source;

d. the radionuclide in each case;

e. the activity of the source at the time of production, first placing on the market or purchase of the source by the licence holder.

[3] The licensing authority shall continuously update the inventory.

Art. 98 Requirements

[1] Before a licence is granted for handling high-activity sealed sources, the applicant must provide evidence that appropriate provision has been made for subsequent disposal.

[2] The licence holder shall verify at least once a year that each high-activity sealed source and, where relevant, its protective container is in good condition and is still present at its place of use or storage. The licence holder shall report the results of the inspection to the licensing authority.

Art. 99 Safety and security

[1] For each high-activity sealed source, the licence holder shall define adequate measures and procedures aimed at preventing unauthorised access to or loss or theft of the source or its damage by fire, and shall document the measures and procedures.

[2] The FDHA, in consultation with ENSI, shall define the principles for the structural, technical, organisational and administrative requirements for safety and security measures.

Section 8 Quality Assurance Measures

Art. 100

[1] The licence holder must ensure that radiation sources:

a. are subjected to testing prior to their first use;

b. are regularly inspected and maintained.

[2] Paragraph 1 also applies to associated medical image receptor systems, image display and image documentation equipment, nuclear medicine examination systems and activimeters.

3 The FDHA may, in consultation with ENSI, define the minimum scope and the periodicity of testing, the minimum scope of the quality assurance programme and the requirements for the implementing bodies. It shall take into account national and international quality assurance standards.

Section 9
Transport and Import, Export and Transit of Radioactive Material

Art. 101 Off-site transport

1 Any person who transports radioactive material, or has it transported, off-site must:

a. comply with federal regulations concerning the carriage of dangerous goods;

b. provide evidence that they have and implement an appropriate quality assurance programme.

2 The consignors and transporters of radioactive material must:

a. each, in advance, designate a person responsible for quality assurance and define quality assurance measures in writing;

b. make sure that the transport containers or packaging materials comply with the relevant regulations and are properly maintained.

3 If the consignors and transporters have in place a quality assurance system for the transport of radioactive material, certified by an accredited body, it shall be assumed that they implement an appropriate quality assurance programme.

4 The consignors must verify that the contracted transporter, if necessary, has a licence for the transport of radioactive material.

Art. 102 On-site transport

The FDHA, in consultation with ENSI, shall specify the requirements for on-site transport of radioactive material.

Art. 103 Import, export and transit

1 Radioactive material may only be imported, exported or undergo transit via the customs offices designated by the Directorate General of Customs.

2 The customs declaration for import, export, or transit must include the following details:

a. the precise designation of the goods;

b. the radionuclides (in the case of nuclide mixtures the three nuclides with the lowest licensing limits must be indicated);

c. the total activity per radionuclide in Bq[36];

36 Bq = becquerel

d. the licence number of the recipient (for imports) or the sender (for exports) in Switzerland.

3 For each individual storage of radioactive material in a customs bonded warehouse or in a duty-free warehouse, the depositor must present to the customs office a licence as specified in Article 28 of the RPA.

4 The licensing authority may request that a separate licence application be submitted for each import, export and transit of high-activity sealed sources.

Section 10 Orphan Radioactive Materials

Art. 104

1 If there is an increased likelihood of orphan radioactive materials being encountered in recyclable materials or wastes, the enterprises concerned are required, when managing or preparing these materials or wastes for export, to inspect them for the presence of orphan radioactive materials using appropriate screening procedures and, if such materials are detected, to secure the recyclable materials or wastes at an appropriate location. This applies in particular to:

a. enterprises where municipal wastes or wastes of similar composition are incinerated;

b. enterprises which recycle scrap metals;

c. enterprises which prepare scrap metals for export.

2 The duties of the enterprises concerned shall be specified in the licence.

Section 11 Clearance

Art. 105 Clearance from mandatory licensing and supervision

Handling of the following shall be cleared from mandatory licensing and supervision:

a. material discharged to the environment in accordance with Articles 111–116;

b. material cleared or discharged to the environment in accordance with the Radiological Protection Ordinance of 22 June 1994[37];

c. material from an activity subject to mandatory licensing cleared in accordance with Article 106;

e. NORM discharged to the environment in accordance with Article 169.

37 [AS **1994** 1947, **1995** 4959 No II 2, **1996** 2129, **2000** 107 934 2894, **2001** 3294 No II 7, **2005** 601 Annex 7 No 3 2885 Annex No 7, **2007** 1469 Annex 4 No 44 5651, **2008** 3153 Art. 10 No 2 5747 Annex No 22, **2010** 5191 Art. 20 No 4 5395 Annex 2 No II 3, **2011** 5227 No I 2.7, **2012** 7065 No I 5 7157, **2013** 3041 No I 5 3407 Annex 6 No 3]

Art. 106 Clearance measurement and other clearance methods

[1] Licence holders may clear the handling of material from mandatory licensing and supervision if they demonstrate by a measurement (clearance measurement) that:

a. the maximum ambient dose rate at a distance of 10 cm from the surface, allowing for natural radiation, is less than 0.1 μSv per hour; and

b. one of the following requirements is met:

1. the specific activity is below the clearance limit,

2. the absolute activity is less than the activity of 1 kg of a material whose specific activity is equal to the clearance limit.

[2] If persons may be contaminated when handling material cleared in accordance with paragraph 1, it must additionally be ensured by a measurement that the surface contamination guidance value specified in Annex 3 Column 12 is complied with.

[3] For the averaging of the values measured in accordance with paragraphs 1 and 2 to ensure non-exceedance of the clearance limit or the surface contamination guidance values specified in Annex 3 Column 12, the following quantities must be complied with:

a. for the measurement of activity: 100 kg;

b. for the measurement of surface contamination: 100 cm^2.

[4] In justified cases, the supervisory authority may approve values higher than those specified in paragraph 3.

[5] Handling of solid or liquid material may be cleared without measurement of activity by technical means if:

a. the maximum ambient dose rate at a distance of 10 cm from the surface, allowing for natural radiation, is less than 0.1 μSv per hour;

b. paragraph 2 is complied with; and

c. one of the following requirements is met:

1. it can be demonstrated that the clearance limit is not exceeded by an assessment of the materials used or by excluding activation,

2. the supervisory authority has approved the models and calculations used to demonstrate that the clearance limit is not exceeded.

[6] The supervisory authority may define the conditions under which the results of a clearance measurement must be reported to it prior to the clearance of the materials.

Art. 107 Prohibition of mixtures

It is not permissible to mix radioactive materials with other materials so that the handling of the mixture is not subject to mandatory licensing and supervision. This is without prejudice to Articles 111–116 and 169.

Chapter 7 Radioactive Waste

Section 1 Principle

Art. 108 Definition

Radioactive waste means radioactive material for which no reuse is foreseen and which does not contain only NORM.

Art. 109 Reuse

[1] A specifically planned use of radioactive material as part of a licensed activity, initiated within three years from the last use, is considered to be reuse. The supervisory authority may approve an extension of this time limit.

[2] The supervisory authority may request that radioactive material be subjected to reuse.

Art. 110 Monitoring and documentation

Licence holders must:

a. monitor their radioactive waste holdings

b. document the activity levels relevant for subsequent treatment and the composition;

c. keep records of radioactive waste discharged to the environment.

Section 2 Discharge to the Environment

Art. 111 Principles

[1] Discharge to the environment comprises, in particular, landfilling, disposal with domestic waste, discharge in exhaust air and wastewater, incineration, reuse or delivery to a recycling facility.

[2] Only low-level radioactive waste may be discharged to the environment.

[3] Radioactive waste may only be discharged to the environment with a licence and under the supervision of the licence holder.

[4] It may only be discharged to the environment by the licence holder without the approval of the licensing authority and without specific licensing in accordance with Article 112 paragraph 2 if:

a. the maximum ambient dose rate at a distance of 10 cm from the surface, allowing for natural radiation, is less than 0.1 µSv per hour;

b. the requirement specified in Article 106 paragraph 2 is met; and

c. the total activity per week and licence is not greater than the activity of 10 kg of a material whose specific activity is equal to the clearance limit.

[5] Prior to the discharge of radioactive waste, labels, hazard warning symbols or other markings indicating radioactivity must be removed.

Art. 112 Discharge in exhaust air and wastewater

[1] Airborne or liquid radioactive substances may be discharged in exhaust air to the atmosphere or in wastewater to surface waters.

[2] The licensing authority shall specify maximum permissible discharge rates and, where appropriate, discharge activity concentrations for each discharge site on a case-by-case basis.

[3] It shall specify the discharge rates and discharge activity concentrations in such a way that the source-related dose constraint in accordance with Article 13 paragraph 3 and the immission limits in accordance with Article 24 are not exceeded.

[4] It may increase by up to a factor of three the discharge activity concentrations in accordance with paragraphs 2 and 3 for discharges into sewers if it can be assured that appropriate dilution is guaranteed at all times prior to discharge into publicly accessible waters.

Art. 113 Control measures

[1] The licensing authority shall specify the monitoring of emissions in the licence in accordance with Article 112 paragraphs 2–4. It may, in the licence, provide for mandatory reporting.

[2] Immission monitoring is governed by Article 191.

[3] The supervisory authority may require the licence holder to conduct additional or special measurements as part of immission monitoring and to report the results.

[4] The supervisory authority may request that a meteorological assessment and local background radiation measurements be carried out before operations are commenced.

[5] The licence holder may, with the approval of the supervisory authority, engage external bodies to carry out monitoring measurements.

Art. 114 Landfilling with the approval of the licensing authority

[1] Radioactive waste may, in individual cases, with the approval of the licensing authority, be disposed of to landfill if:

a. overall, taking into account other materials present in the landfill, the clearance limit is not exceeded; or

b. at no time can an effective dose of 10 µSv per calendar year be accumulated as a result of the disposal.

[2] The FOPH shall monitor compliance with the permissible effective dose via the sampling and measurement programme specified in Article 193.

[3] The specific activity of radioactive waste thus disposed of must not exceed 100 times the clearance limit and, for waste containing artificial radium, 1000 times the clearance limit.

[4] For the disposal of radioactive waste containing technically enhanced radium, the following conditions must additionally be met:

a. The waste arose before 1 October 1994.

b. Disposal via the usual channels would be impossible or would involve disproportionate efforts.

c. Removal represents a significantly better option for people and the environment overall than maintenance of the status quo.

Art. 115 Recycling with the approval of the licensing authority

The licensing authority may specify conditions for recycling radioactive waste, in particular metals, with a specific activity no greater than 10 times the clearance limit if it can be assured that the materials arising after the planned recycling do not exceed the clearance limit.

Art. 116 Incineration with the approval of the licensing authority

[1] Combustible radioactive waste may, with the approval of the licensing authority, be incinerated at thermal waste treatment plants in accordance with the Waste Ordinance of 4 December 2015[38] if:

a. compliance with the clearance limit can be demonstrated by monitoring of activity concentrations or calculation of the possible contamination of incineration residues;

b. the radioactive waste only contains the radionuclides H-3 or C-14; and

c. the activity approved for incineration per week does not exceed 1000 times the licensing limit.

[2] In justified cases, the licensing authority may approve the incineration of combustible radioactive waste containing radionuclides other than those specified in paragraph 1 letter b.

Section 3 Treatment of Radioactive Waste

Art. 117 Decay storage

[1] Radioactive waste exclusively containing radionuclides with a half-life of 100 days or less must, whenever possible, be retained at the sites where it arises until its activity has decayed to such an extent that it can be measured for clearance in accordance with Article 106 or discharged within the licensed discharge rate in accordance with Article 112 paragraph 2.

38 SR **814.600**

2 In the absence of an alternative that is more favourable overall for people and the environment, radioactive waste whose activity, as a result of radioactive decay, will have decreased no later than 30 years after the end of use of the original material to such an extent that it can be measured for clearance in accordance with Article 106 or recycled in accordance with Article 115 must be stored until this point has been reached. It must be separated from radioactive waste which does not fulfil this condition.

3 During the decay period, waste as specified in paragraphs 1 and 2 must be:

a. packaged and stored in such a way as to prevent the uncontrolled release of radioactive substances and avoid creating a fire hazard;

b. marked and provided with documentation indicating the type of waste, activity content and time of possible clearance.

4 Prior to clearance, it must be ensured that Article 106, or Article 112 or 115, is complied with.

5 The licensing authority shall specify the technical requirements for decay storage and any related activities.[39]

Art. 118 Gases, dust, aerosols and liquids

1 Radioactive waste in the form of gases, dust or aerosols which may not be discharged to the environment must be retained by suitable technical devices.

2 Liquid radioactive waste which may not be discharged to the environment must be converted to a chemically stable solid form.

3 The supervisory authority may grant exemptions from paragraphs 1 and 2 or permit additional treatment options if an alternative more favourable for people and the environment can thereby be realised.

Section 4 Delivery of Radioactive Waste

Art. 119 Radioactive waste subject to mandatory delivery

1 Radioactive waste not arising as a result of the use of nuclear energy must, following any treatment which may be required in accordance with Article 118, be delivered to the federal collection centre.

2 The following are exempted from delivery to the federal collection centre:

a. radioactive waste which may be discharged to the environment;

b. radioactive waste with a short half-life as specified in Article 117.

3 The FDHA shall define the technical details for the treatment of radioactive waste subject to mandatory delivery prior to its receipt by the federal collection centre.

39 Inserted by No II of the O of 7 Dec. 2018, in force since 1 Feb. 2019 (AS **2019** 183).

Art. 120 Designation and duties of the federal collection centre

[1] The federal collection centre shall be operated by the Paul Scherrer Institute (PSI).

[2] The PSI shall take receipt of radioactive waste subject to mandatory delivery and be responsible for stacking, treatment and interim storage.

Art. 121 Coordination group

A coordination group comprising representatives from the FOPH, ENSI and the PSI shall make recommendations to the supervisory and licensing authorities on ensuring the safe receipt of radioactive waste subject to mandatory delivery.

Chapter 8 Failures

Section 1 Definition

Art. 122

Failure means an event which involves the deviation of an installation, article or activity from normal operation, and which:

a. compromises the safety of the installation or article;

b. may lead to the exceedance of an immission or emission limit; or

c. has or could have led to the exceedance of a dose limit.

Section 2 Preparedness

Art. 123 Design of enterprises

[1] The licence holder must adopt appropriate measures to prevent failures.

[2] The enterprise must be designed in such a way that the following requirements are met:

a. For failures with an expected frequency of more than 10^{-1} per year, it must be possible for the source-related dose constraints specified in the licence to be complied with.

b. For failures with an expected frequency of between 10^{-1} and 10^{-2} per year, a single such event must not lead to an additional dose which exceeds the relevant source-related dose constraints.

c. For failures with an expected frequency of between 10^{-2} and 10^{-4} per year, the dose resulting from a single such event for members of the public must not be greater than 1 mSv.

d. For failures with an expected frequency of between 10^{-4} and 10^{-6} per year, the dose resulting from a single such event for members of the public must not be greater than 100 mSv; the licensing authority may specify a lower dose in individual cases.

3 The enterprise must be designed in such a way that only a small number of failures as specified in paragraph 2 letters c or d can occur.

4 For failures as specified in paragraph 2 letters c and d and for failures which have an expected frequency of less than 10^{-6} per year, but which could have major impacts, the supervisory authority shall require the enterprise to adopt the necessary preparedness measures.

5 The supervisory authority shall specify on a case-by-case basis the methodology and boundary conditions for the analysis of failures and for their assignment to the frequency classes specified in paragraph 2 letters b–d. The effective dose or the equivalent doses arising from failure-related exposure of persons must be determined in accordance with the current state of science and technology, using the assessment quantities and dose coefficients specified in Annexes 3, 5 and 6.

6 For enterprises where failures as specified in paragraph 2 letter d may occur, the supervisory authority may order:

a. the measurement of installation parameters which are required to monitor the course of an accident, to produce diagnoses and forecasts, and to determine the measures necessary to protect the public;

b. the continuous transmission of the installation parameters to the supervisory authorities via a network tolerant of an failure.

Art. 124 Safety report

1 The supervisory authority may require the licence holder to submit a safety report.

2 The safety report shall include descriptions of:

a. the safety systems and equipment;

b. the measures adopted to ensure safety;

c. the enterprise organisation responsible for safety and radiological protection;

d. failures, their effects on the enterprise and the surrounding area, and their approximate frequency;

e. emergency response planning for protection of the public, in the case of enterprises as specified in Article 136.

3 The supervisory authority may request additional documentation.

Art. 125 Preparedness measures

1 Licence holders must make the necessary internal preparations so that failures and their effects can be managed.

2 They must issue directives concerning the emergency measures to be adopted.

3 They must ensure that appropriate resources are available at all times for the management of failures and their effects; in rooms where radioactive materials are handled, this also applies to firefighting.

4 They must ensure that staff receive regular instruction on rules of behaviour, are trained in emergency measures and are familiarised with the location and use of the relevant resources.

5 They must take appropriate measures to ensure that, in a particular case, the persons deployed to manage failures and their effects do not receive an effective dose of more than 50 mSv or, to save human lives, more than 250 mSv.

6 They must inform the competent cantonal authorities and emergency services of the radioactive materials present in the enterprise.

7 The supervisory authority may require that exercises be conducted to test reporting channels, the functionality of resources and the necessary skills of staff. It may organise exercises itself.

Section 3 Management

Art. 126 Licence holders' emergency measures

1 Licence holders must make every effort to manage failures and their effects.

2 In particular, they must, without delay:

a. control the extent of the failure, in particular by taking measures at source;

b. ensure that all persons not involved in the management of the failure do not enter the danger zone or leave it immediately;

c. take measures to protect the staff deployed, such as dose monitoring and appropriate instruction;

d. ensure that all those involved are registered, monitored for contamination and intakes, and if necessary decontaminated.

3 They must, as soon as possible:

a. remove any contamination which has arisen;

b. take the measures required to clarify the cause of the failure.

Art. 127 Licence holders' reporting duties

Licence holders must report failures in a timely manner, as follows:

a. every failure: to the supervisory authority;

b. failures as specified in Article 122 letter b: in addition, to the National Emergency Operations Centre (NEOC);

c. failures within the area supervised by Suva: in addition, to the FOPH;

d. failures leading to an exceedance of the dose limit for occupationally exposed persons in the enterprise: to Suva.

Art. 128 Duties of the supervisory authority

[1] The supervisory authority shall assess the failure. Within the area supervised by Suva, the FOPH must be informed of the assessment.

[2] The supervisory authority shall forward to the authorities concerned any information on failures which is required for the fulfilment of a responsibility.

[3] ENSI shall report to the IAEA the rating of a failure on the International Nuclear and Radiological Event Scale (INES)[40] from Level 2 upwards.

Art. 129 Licence holders' investigation and reporting

[1] After an failure, licence holders must carry out an investigation without delay.

[2] The results of the investigation must be recorded in a report. The report must contain:

a. a description of the failure, the cause, the effects determined and other possible effects, and the measures taken;

b. an account of measures which are planned or have already been taken to prevent further similar failures.

[3] The licence holder shall submit the report to the supervisory authority no later than six weeks after the failure.

Art. 130 Measures in the event of exceedance of an immission limit

If the FOPH determines that an immission limit has been exceeded, it shall ascertain the cause and take the necessary measures.

Art. 131 Provision of information on failures

The supervisory authority shall ensure that the persons and the cantons concerned and the public are informed about failures in a timely manner.

Title 3 Emergency Exposure Situations

Chapter 1 Definition and Reference Levels

Art. 132 Definition

Emergency means an failure as defined in Article 122, or another event involving increased radioactivity, which necessitates immediate action to mitigate or avert

40 The event scale can be consulted on the website of the Swiss Federal Nuclear Safety Inspectorate (ENSI) at: www.ensi.ch > Emergency Preparedness > INES levels.

serious adverse consequences for human health and safety, living conditions and the environment.

Art. 133 Reference levels for the public

[1] In emergency exposure situations, a reference level of 100 mSv in the first year applies for members of the public.

[2] The Federal Civil Protection Crisis Management Board (CCMB), which is responsible for dealing with incidents of national importance relevant to the protection of the population in accordance with the Ordinance of 2 March 2018[41] on the Federal Civil Protection Crisis Management Board (CCMBO), may request the Federal Council to set a lower reference level, depending on the specific situation.[42]

Art. 134 Reference levels for persons with special responsibilities

[1] In emergency exposure situations, a deployment-related reference level of 50 mSv per year applies for persons with special responsibilities.

[2] The CCMB[43] may request the Federal Council to set lower reference levels, depending on the specific situation, for particular activities performed by persons with special responsibilities.

[3] For saving human lives, preventing serious damage to health or averting disasters, a reference level of 250 mSv per year applies.

Chapter 2 Measures

Art. 135 Implementation of emergency preparedness

[1] The Federal Office for Civil Protection (FOCP), together with the competent authorities and the cantons, is responsible for preparing the national emergency response plan.

[2] The FOPH, in cooperation with the FOCP, shall prepare the radiological protection strategy for the national emergency response plan. This must be based on reference levels. For nuclear power plant scenarios, ENSI shall provide the necessary foundations.

41 SR **520.17**

42 Amended by Annex 3 No II 4 of the O of 2 March 2018 on the Federal Civil Protection Crisis Management Board, in force since 1 April 2018 (AS **2018** 1093).

43 Term in accordance with Annex 3 No II 4 of the O of 2 March 2018 on the Federal Civil Protection Crisis Management Board, in force since 1 April 2018 (AS **2018** 1093). This amendment has been made throughout the text.

3 The FOCP, together with the FOPH, is responsible for preparing the sampling and measuring organisation specified in Article 4*a* of the Ordinance of 17 October 2007[44] on the National Emergency Operations Centre (ONEOC).

4 The FOPH is responsible for preparing the measures required for the protection of public health. This is without prejudice to preparations for protective measures during the acute phase as specified in the CCMBO[45].

5 The FOPH is responsible for the maintenance of knowledge on the treatment of severely irradiated persons.

6 The FOPH and ENSI, together with the NEOC, shall develop methods and models for determining radiation doses.

Art. 136 Preparation of emergency response measures in the vicinity of enterprises

1 For enterprises where, given the licensed quantity and activity of radionuclides, an emergency may occur, the licensing authority shall specify on a case-by-case basis to what extent they are required to participate in preparing and implementing emergency response measures in the surrounding area, or to adopt such measures themselves.

2 The licensing authority shall involve the competent cantonal authorities and emergency services in preparing emergency response measures and inform them of the measures adopted.

3 For warnings and alerts and for preparing and implementing measures to protect against increased radioactivity in the vicinity of nuclear installations, the Emergency Response Ordinance of 20 October 2010[46] and the Alerts and Safety Radio Network Ordinance of 18 August 2010[47] apply.

Chapter 3 Management

Art. 137 Reporting duty

The FOPH shall report an emergency to the World Health Organization (WHO) in accordance with the International Health Regulations (2005) adopted on 23 May 2005[48].

44 [AS **2007** 4953, **2010** 5395 Annex 2 No II 2, **2018** 1093 Annex 2 No II 2 4953 Annex 5 No II 2. AS **2020** 5087 Annex 3 No I 3]. See now the O of 11 Nov. 2020 on civil protection (SR **520.12**).

45 SR **520.17**. Term in accordance with Annex 3 No II 4 of the O of 2 March 2018 on the Federal Civil Protection Crisis Management Board, in force since 1 April 2018 (AS **2018** 1093). This amendment has been made throughout the text.

46 [AS **2010** 5191, **2018** 4335. AS **2018** 4953 Annex 5 No I]. See now the O of 14 Nov. 2018 (RS **732.33**).

47 [AS **2010** 5179 5191 Art. 20 No 2, **2013** 4475, **2017** 605, **2018** 4953 Annex 5 No II 1. AS **2020** 5087 Annex 3 No I 1]. See now the O of 11 Nov. 2020 on civil protectiopn (SR **520.12**).

48 SR **0.818.103**

Art. 138 Duty to provide information

The supervisory authority shall ensure that information on emergencies is provided in a timely manner to the persons concerned at the enterprise, the public and the cantons concerned.

Art. 139 Determination of radiation doses

[1] The FOPH is responsible for the calculation, assessment and verification of radiation doses to the public. In the acute phase of a crisis, the NEOC shall assume this responsibility in accordance with the Civil Protection Ordinance of 11 November 2020[49].[50]

[2] For simplified dose calculations, the dose coefficients specified in Annexes 5 and 6 apply.

Art. 140 Management in emergency exposure situations

[1] In emergency exposure situations, the CCMB is responsible for management in accordance with the CCMBO[51]. It shall take into account the implementation of emergency preparedness as specified in Article 135.

[2] In a crisis, the NEOC shall deploy the sampling and measuring organisation specified in Article 4*a* paragraph 4 of the ONEOC[52].

[3] The FOPH shall support the NEOC in preparing monitoring programmes.

[4] The FOPH shall advise the CCMB on ordering measures to protect public health.

Art. 141 Transition to an existing or planned exposure situation

The CCMB, on the basis of the radiological situation, shall request the Federal Council to order the transition from an emergency exposure situation to an existing or planned exposure situation.

Chapter 4 Persons with Special Responsibilities

Art. 142 Groups of persons

[1] In an emergency exposure situation, the following are required to assume responsibility for tasks in accordance with Article 20 paragraph 2 letter b of the RPA:

a. members of authorities and administrative bodies;

49 [AS **2010** 5179 5191 Art. 20 No 2, **2013** 4475, **2017** 605, **2018** 4953 Annex 5 No II 1. AS **2020** 5087 Annex 3 No I 1]. See now the O of 11 Nov. 2020 on civil protectiopn (SR **520.12**).
50 Amended by Annex 3 No II 8 of the Civil Protection Ordinance of 11 Nov. 2020, in force since 1 Jan. 2021 (AS **2020** 5087).
51 SR **520.17**
52 SR **520.18**

b. members of the police, professional fire services, emergency medical services, civil protection and army;

c. persons and undertakings such as monitoring and radiological protection teams, for direct intervention;

d. persons and undertakings in the public and private transport sector, for passenger and freight transport and evacuations;

e. persons and undertakings, for indirect intervention, such as at-source measures designed to prevent further contamination of the surrounding area;

f. healthcare professionals and medical staff, for the care of radiation victims or other persons affected;

g. persons and undertakings required to sustain critical infrastructure;

h. persons and undertakings required to sustain indispensable public services.

2 For the protection of members of voluntary fire services, Articles 134 and 143–146 apply.

3 Persons under 18 years of age and pregnant women shall be exempted from tasks as specified in paragraph 1.

Art. 143 Protection of health

1 The radiation exposure of persons with special responsibilities must be determined at appropriate intervals by means of suitable measurements.

2 If persons with special responsibilities have received an effective dose of more than 250 mSv, they must be placed under medical surveillance.

3 The medical surveillance and duties in the event of an exceedance are governed by Article 59 paragraphs 2–5.

Art. 144 Instruction

1 In an emergency exposure situation, persons with special responsibilities must receive appropriate instruction. The FDHA, in consultation with ENSI and the Federal Department of Defence, Civil Protection and Sport (DDPS), shall specify:

a. the goals of instruction;

b. the radiological protection activities which the persons may perform on the basis of their instruction.

2 The authorities, administrative bodies, organisations and undertakings concerned are responsible for providing instruction.

Art. 145 Equipment

1 The persons with special responsibilities must have the equipment required for performing their tasks and protecting their health. The CCMB shall serve a coordinating function with regard to equipment.

2 The required equipment shall include in particular:

a. an adequate number of measuring instruments and dosimeters to determine radiation exposure;

b. means of protection against intakes or contamination.

Art. 146 Insurance cover and compensation

1 In the event of increased radioactivity, persons with special responsibilities are insured against accidents and illness.

2 If the cover provided by compulsory accident insurance and existing private insurance is not sufficient, the Confederation shall guarantee benefits in accordance with the provisions of the Federal Act of 19 June 1992[53] on Military Insurance. If necessary, the military insurance organisation may be involved for purposes of implementation.

3 If, as a result of their activities, persons and undertakings with special responsibilities incur costs that are not covered, they shall receive compensation from the Confederation. The DDPS shall regulate the processing of financial claims.

Chapter 5
Exceedance of Maximum Concentrations for Radionuclides in Foods

Art. 147

1 If, in an emergency exposure situation or in the subsequent existing exposure situation, the cantonal enforcement authorities determine an exceedance of a maximum concentration for radionuclides in foods in accordance with the food legislation, they shall take measures as specified in the food legislation and inform the Federal Food Safety and Veterinary Office (FSVO).

2 The FSVO shall inform the FOPH and the other cantons of reports received in accordance with paragraph 1.

Title 4 Existing Exposure Situations

Chapter 1 Principles

Art. 148

1 For existing exposure situations, a reference level of 1 mSv per calendar year applies. This is without prejudice to the radon reference level specified in Article 155 and the threshold level specified in Article 156.

53 SR **833.1**

2 The FOPH may recommend to the Federal Council, in individual cases, reference levels of up to 20 mSv per calendar year, in particular if measures are required in accordance with Article 171.

Chapter 2 Radiological Legacies

Section 1 Definition

Art. 149

Radiological legacies means:

a. articles from past activities containing radionuclides which would be classified as radioactive material under this Ordinance;

b. articles whose type licence for general or restricted use in accordance with Article 29 letter c of the RPA has expired and is not renewed;

c. properties contaminated from past activities where the requirements specified in this Ordinance are not met.

Section 2 Articles

Art. 150

1 The FOPH is responsible for the disposal of radiological legacies in the form of articles. This disposal is governed in other respects by Articles 108–121.

2 Further use of these articles is permissible if a licence has been granted to this effect.

Section 3 Properties

Art. 151 Inventory of properties with possible contamination

1 The FOPH shall maintain an inventory of possibly contaminated properties and shall process the following data to this end:

a. details of the property (geographical coordinates, plot number, building and substrate);

b. details of earlier activities on the property, including the period;

c. investigation data;

d. data on the owner and the user of the property (name, address, postcode, place);

e. remediation decision;

f. remediation data and results of clearance measurements after remediation, including any restrictions.

2 To fulfil the responsibilities assigned to them, the staff of the FOPH Radiological Protection Division shall have electronic access to the inventory data.

3 The FOPH shall regularly inform Suva and the cantons concerned as to the status of the inventory.

Art. 152 Investigation of properties

1 The FOPH shall order an investigation of properties as specified in Article 151 if a risk to people and the environment from ionising radiation cannot be ruled out. It shall inform in advance the canton and the commune concerned.

2 The owners and users are required to grant the FOPH access to the properties concerned for the investigation.

3 The FOPH shall specify the investigation procedure.

4 It shall carry out the investigations. It may request third parties to carry out the investigations.

Art. 153 Remediation of properties

1 On the basis of the investigation, the FOPH shall estimate the effective dose to persons who may be present in the building.

2 The FOPH shall inform the persons concerned, the owner and user of the property, and the canton and commune concerned as to the results of the investigation.

3 If the dose is above the reference level as specified in Article 148 paragraph 1, the FOPH shall declare the property to be in need of remediation and shall inform the owner accordingly.

Art. 154 Exchange of information

1 The FOPH shall inform the cantons concerned as to possible radiological legacies.

2 The cantons shall inform the FOPH of planned studies, monitoring measures and remediations of contaminated sites if there is an increased likelihood that radiological legacies are present. This is the case in particular if radium-containing luminous paint was used by industry.

Chapter 3 Radon

Section 1 General Provisions

Art. 155 Radon reference level

1 The radon reference level is the radon gas concentration which, if exceeded, requires measures to be taken in accordance with Article 166.

2 For the annual average radon gas concentration in rooms where persons are regularly present for several hours per day, a radon reference level of 300 Bq/m^3 applies. This is without prejudice to the provisions of Article 156.

Art. 156 Threshold level at radon-exposed workplaces

1 The threshold level at radon-exposed workplaces is the radon gas concentration which, if exceeded, requires measures to be taken in accordance with Article 167.

2 For the annual average radon gas concentration at radon-exposed workplaces, a threshold level of 1000 Bq/m^3 applies.

3 Workplaces at which the threshold level is certainly or presumably exceeded are considered to be radon-exposed. These are, in particular, workplaces in underground structures, mines, caverns and water supply installations, as well as those classified as radon-exposed by the supervisory authority.

Art. 157 Radon Technical and Information Centre

1 The FOPH shall operate a Radon Technical and Information Centre.

2 The Centre shall carry out, in particular, the following tasks:

a. regularly issuing recommendations on mitigation measures and supporting the cantons in implementation;

b. publishing the radon map in consultation with the cantons;

c. providing information and advice for the cantons, building owners, tenants, construction professionals and other interested groups;

d. advising persons concerned and interested bodies on appropriate mitigation measures;

e. regularly providing the cantons with an overview of buildings where measurements have been conducted;

f. approving and supervising radon measurement providers in accordance with Article 159;

g. establishing the scientific foundations required for the application of radon mitigation measures;

h. regularly evaluating the effects of mitigation measures and making the necessary adjustments.

3 The FOPH may request third parties to provide advice in accordance with paragraph 2 letter d.

Art. 158 Responsibility

The following are responsible for the enforcement of radon mitigation measures:

a. in rooms where persons are regularly present for several hours per day (Art. 155 para. 2):

1. the cantons,

2. in the case of military buildings: the DDPS;

b. at radon-exposed workplaces as specified in Article 156: the supervisory authorities.

Art. 159 Approval of radon measurement providers

[1] Radon measurements must be conducted by an approved radon measurement provider in accordance with prescribed measurement protocols.

[2] The FOPH shall approve a radon measurement provider if it:

a. has the specialist staff and measurement system required for due fulfilment of its responsibilities; and

b. can assure proper fulfilment of its responsibilities, and in particular if no conflicts of interest exist.

[3] The FOPH shall grant approval for a maximum period of five years.

[4] The FDJP shall specify the technical requirements for measurement systems and the methods for maintenance of measurement stability.

Art. 160 Duties of radon measurement providers

Approved radon measurement providers are required:

a. to comply with the prescribed measurement protocols;

b. to enter their data in the radon database within two months after the completion of measurements.

Art. 161 Radon consultants

[1] Radon consultants shall support and advise clients, construction professionals, building owners and other interested parties on the implementation of preventive and remedial measures for radon mitigation according to the state of the art.

[2] The FOPH shall maintain a list in which radon consultants working in Switzerland who have undergone training and continuing education in accordance with Article 183 letter c are included on request. It shall publish the list[54] and regularly update it.

Art. 162 Radon database

[1] The FOPH shall maintain a central radon database. In this database, it shall store the data which is required to allow continuous assessment of the implementation of measurements and remediation projects and to draw statistical and scientific conclusions.

[2] The following data on individual buildings shall be stored in the central radon database:

[54] The list may be consulted free of charge on the FOPH website at www.bag.admin.ch > Topics > People & health > Radiation, radioactivity & sound > Radon > Advice by radon consultants.

a. location (coordinates, plot number);

b. Swiss federal building identifier (EGID) and dwelling identifier (EWID) in accordance with the Ordinance of 31 May 2000[55] on the Federal Register of Buildings and Dwellings;

c. information on the premises;

d. measurement data;

e. remediation data;

f. owner and user (name, address, postcode, place);

g. year of construction.

3 The staff of the FOPH Radon Technical and Information Centre are entitled to process the data in the database.

4 To fulfil the responsibilities assigned to them, the following shall have electronic access to data in the database as specified below:

a. the approved radon measurement providers: to the data which they have collected themselves;

b. the cantons: to all data collected on their territory;

c. Suva: to all data collected at workplaces.

5 The FOPH may, on the basis of a data protection agreement, make available to third parties data from the radon database for research purposes subject to the following requirements and conditions:

a. The data shall be anonymised as soon as the purpose of processing permits.

b. The data shall not be transferred.

c. If the results are published, this must be done in a completely anonymised form.

Section 2
Preventive Mitigation Measures and Radon Measurements

Art. 163 Radon mitigation in new buildings and building alterations

1 In the course of the permission procedure for new buildings and building alterations, the building permission authority shall, where appropriate, draw the attention of the building owner or, in the case of new buildings, the client to the requirements of this Ordinance concerning radon mitigation.

2 The building owner or, in the case of new buildings, the client shall ensure that preventive structural measures are taken in accordance with the state of the art to achieve a radon gas concentration below the reference level specified in Article 155

55 [AS **2000** 1555, **2004** 3367, **2005** 3381, **2007** 3399 6719 Annex No 7, 2012 4707. AS **2017** 3459 Annex No 2 I]. See Now the O of 9 June 2017 (RS **431.841**).

paragraph 2. If the current state of science and technology so requires, a radon measurement must be conducted in accordance with Article 159 paragraph 1.

Art. 164 Cantonal radon measurements

1 The canton may require the building owner to have radon measurements conducted in rooms where persons are regularly present for several hours per day.

2 The canton shall ensure that radon measurements are conducted in schools and nursery schools in accordance with Article 159 paragraph 1.

3 The canton may conduct further radon measurements.

4 In the case of military buildings, the DDPS is responsible for ordering radon measurements.

Art. 165 Radon measurements at radon-exposed workplaces

1 Enterprises with radon-exposed workplaces shall ensure that measurements are conducted by an approved radon measurement provider in accordance with Article 159 paragraph 1.

2 The supervisory authority may conduct spot-check measurements at radon-exposed workplaces.

Section 3 Measures to Reduce Radon Exposure

Art. 166 Radon remediation

1 If the reference level specified in Article 155 paragraph 2 is exceeded, the building owner shall take the necessary remedial measures. Recommendations concerning the urgency of remedial measures shall be provided by the FOPH and the cantons.

2 If the building owner fails to take action, the canton may order radon remediation.

3 If it is determined that the reference level is exceeded at a school or nursery school, the canton shall order radon remediation within three years after the time of determination.

4 The costs of remediation shall be borne by the building owner.

Art. 167 Workplace measures

1 If the threshold level specified in Article 156 is exceeded, the enterprise must determine the annual radon-related effective dose to exposed persons and review this at least every five years.

2 If the effective dose to a person at the workplace is above 10 mSv per calendar year, the enterprise shall take organisational or technical measures to reduce the dose as rapidly as possible.

3 If, in spite of measures being taken, the effective dose to a person at the workplace is above 10 mSv per calendar year, this person is considered to be occupationally exposed.

4 The FDHA, after a hearing with Suva, shall specify how the annual radon-related effective dose is to be determined.

Chapter 4 Naturally Occurring Radioactive Material (NORM)

Art. 168 Industrial sectors concerned

1 Industrial sectors involving NORM are, in particular:

a. groundwater filtration facilities;

b. gas production;

c. geothermal energy production (deep geothermal energy);

d. zircon and zirconium industry;

e. cement production and maintenance of clinker ovens;

f. maintenance and removal of heat-resistant zirconium alloy cladding;

g. tunnelling in rock formations with elevated uranium or thorium concentrations.

2 In industrial sectors involving NORM, enterprises shall determine by means of representative measurements whether:

a. the NORM clearance limit is exceeded in discharged materials;

b. staff are occupationally exposed persons as defined in Article 51 paragraphs 1 and 2;

c. the handling of NORM may lead to a dose for members of the public which is not negligible from a radiological protection point of view.

3 The enterprises shall submit evidence of the tests conducted in accordance with paragraph 2 and the results thereof to the FOPH.

4 The FOPH shall support the enterprises in the determination of the situations specified in paragraph 2 letters b and c.

5 In industrial sectors involving NORM, the FOPH and Suva may conduct spot-check measurements.

Art. 169 Discharge of NORM to the environment

1 NORM with a specific activity above the relevant NORM clearance limit may, with the approval of the licensing authority, be discharged to the environment if:

a. disposal via the usual channels would be impossible or would involve disproportionate effort; and

b. as a result of appropriate measures, the effective dose to members of the public arising from the discharge remains below 0.3 mSv per calendar year.

[2] The FOPH shall monitor compliance with the permissible effective dose via the sampling and measurement programme specified in Article 193.

[3] NORM may only be exported for discharge to the environment if consent has been granted by the competent authority of the recipient country and the requirements specified in paragraph 1 are complied with.

Art. 170 Building materials

[1] For building materials identified as being of concern from a radiological protection point of view, the FOPH shall, to determine public exposure, establish by means of spot checks whether the activity concentration index is greater than 1.

[2] If the activity concentration index is greater than 1, the FOPH shall carry out a dose estimation to ensure that the reference level specified in Article 148 is complied with.

[3] The FOPH shall inform the public of the results.

Chapter 5 Long-Term Contamination following an Emergency

Art. 171

The FOPH shall prepare the long-term federal and cantonal measures for the management of effects after the transition from an emergency exposure situation to an existing exposure situation in accordance with Article 141.

Title 5 Training and Continuing Education

Chapter 1 General Provisions

Art. 172 Persons who must undergo training and continuing education

[1] The following persons must undergo radiological protection training and continuing education in line with their activities and responsibility:

a. persons who are involved in the handling of ionising radiation, who may be exposed to it in the course of their specific activities, or who plan or order the handling thereof and, in the process, define radiological protection measures for self-protection;

b. persons who have radiological protection responsibilities vis-à-vis third parties;

c. radiological protection experts;

d. radon consultants as specified in Article 161 paragraph 1;

e. persons who, in the case of a failure or emergency, are involved in the handling of ionising radiation, may be exposed to it, or plan or order the handling thereof, or operate critical infrastructure or provide public services.

2 The FDHA may, in consultation with ENSI and the DDPS, regulate exemptions from mandatory continuing education for the handling of ionising radiation with a low hazard potential.

Art. 173 Responsibility for training and continuing education

1 The following are responsible for training and continuing education:

a. for persons specified in Article 172 paragraph 1 letters a–c: the licence holders;

b. for radon consultants as specified in Article 172 paragraph 1 letter d: these persons themselves;

c. for persons specified in Article 172 paragraph 1 letter e: the relevant authorities, administrative bodies, organisations and undertakings; they shall ensure that, in accordance with their size and structure, an adequate number of persons who have undergone training and continuing education is available.

2 The parties responsible are required to coordinate and document employees' training and continuing education activities. The documentation must be retained until the end of their employment at the enterprise.

Art. 174 Training

1 Persons specified in Article 172 paragraph 1 letters b–d who work in the medical, industrial and nuclear energy sectors require recognised radiological protection training including an examination.

2 The FDHA, in consultation with ENSI and the DDPS, shall determine which persons require what training.

3 The FDHA, in consultation with ENSI and the DDPS, shall specify whether the training for persons specified in Article 172 paragraph 1 letters a and e requires recognition.

Art. 175 Continuing education

1 Continuing education is concerned with the knowledge and skills already acquired in the course of training. Continuing education must ensure that skills, knowledge and awareness of the state of the art and its application in practice are maintained and brought up to date.

2 Persons subject to mandatory continuing education must undergo a course of continuing education at least every five years.

3 The FDHA, in consultation with ENSI and the DDPS, may, taking into account the hazard potential:

a. specify shorter or longer intervals for continuing education courses;

b. specify that the continuing education must be recognised.

Art. 176 Training and continuing education courses

[1] The supervisory authorities and the PSI shall conduct training and continuing education courses as required.

[2] The supervisory authorities may request other agencies or institutions to conduct training and continuing education courses.

[3] The DDPS shall coordinate the training and continuing education courses for persons who, in the case of an failure or emergency, are involved in the handling of ionising radiation, may be exposed to it, or plan or order the handling thereof, or operate critical infrastructure or provide public services.

[4] The supervisory authorities and the DDPS may, within their area of responsibility, require that the persons responsible for training and continuing education in accordance with Article 173 report the date and the form, content and extent of training and continuing education provided for persons subject to mandatory training and continuing education.

Art. 177 Financial assistance

[1] Within the limits of its approved budget, the FOPH may provide financial assistance for training or continuing education courses in radiological protection conducted by third parties, in particular by schools, professional organisations and industry.

[2] Financial assistance shall only be provided if the training or continuing education has been recognised by the supervisory authority.

[3] Financial assistance shall be calculated so that, taken together with other revenues, it does not exceed the course organiser's documented costs.

Art. 178 Recognition of individual training and continuing education

The supervisory authority shall recognise as equivalent individual training or continuing education which a person has received abroad or for a different activity if the acquired knowledge and skills meet the requirements specified in Chapter 2 of this Title.

Art. 179 Training and continuing education database

[1] The FOPH shall maintain a training and continuing education database, in which the following persons subject to mandatory training and continuing education are registered:

a. persons who meet the requirements for being able to serve as radiological protection experts;

b. radiological protection specialists and radiological protection technicians as specified in Article 183 letter b;

c. persons who require recognised continuing education as specified in Article 182 or 183;

d. radon consultants as specified in Article 161 paragraph 1.

2 The purpose of the database is:

a. to make available the information required for granting licences on the occupational training, recognised radiological protection training and continuing education of the person concerned;

b. to simplify the administrative procedures required for granting licences;

c. to simplify supervision by the authorities in the area of individual training and continuing education.

3 The following data concerning persons registered in accordance with paragraph 1 shall be stored in the database:

a. name, former name, first name;

b. date of birth;

c. place of origin (for foreign nationals: place of birth and nationality);

d. occupational training;

e. type, venue and date of radiological protection training courses;

f. type, venue and date of radiological protection continuing education courses;

g. for individual training and continuing education as specified in Article 178: date of recognition of equivalence.

4 The responsible staff of the supervisory authorities are entitled to process online the data of persons within their area of supervision.

5 Training institutions which offer recognised radiological protection courses may record and retrieve online the data concerning persons who have completed their training or continuing education at the institution concerned. They may modify data concerning such persons relating to courses which they have conducted themselves.

6 The FOPH shall enable the persons concerned to access electronically their own data in the training and continuing education database.

Art. 180 Recognition authorities

1 The supervisory authorities specified in Article 184 are responsible for the recognition of training and continuing education courses.

2 The General Secretariat of the DDPS (GS DDPS) is responsible for the recognition of training and continuing education courses for persons who exclusively in the case of an failure or emergency are involved in the handling of ionising radiation, may be exposed to it, or plan or order the handling thereof, or operate critical infrastructure or provide public services.

3 In the event of uncertainty concerning responsibility for recognition, the FOPH, ENSI, Suva and the GS DDPS shall consult each other.

[4] Training and continuing education courses which are offered by a recognition authority must be recognised by a different recognition authority.

[5] The recognition authorities specified in paragraphs 1 and 2 are entitled, in the course of their recognition activities, to monitor the training and continuing education requirements of persons concerned and to assess the quality of training and continuing education courses.

Chapter 2
Content of Regulation and Categories of Persons Subject to Mandatory Training and Continuing Education

Art. 181 Content of regulation in general

[1] The FDHA shall regulate training and continuing education. In particular, it shall define:

a. the objectives, the requirements and the extent of training and continuing education in radiological protection;

b. the skills and knowledge to be acquired by persons who must undergo training and continuing education in accordance with Article 172;

c. the training and continuing education specified in Articles 174–176, 178, 182 and 183 which requires recognition;

d. the requirements for recognition of training and continuing education as specified in letter c;

e. the content of examinations and the examination procedure;

f. the activities permissible for persons with radiological protection training and continuing education which requires recognition.

[2] It shall regulate training and continuing education for persons in non-medical sectors, in consultation with ENSI and the DDPS.

Art. 182 Categories of persons subject to mandatory training and continuing education in the medical sector

[1] The requirements specified by the FDHA for training and continuing education in radiological protection in the medical sector shall be differentiated according to the following categories of persons responsible for radiological protection for patients or animals:

a. persons who prescribe diagnostic applications of ionising radiation in medicine and chiropractic;

b. physicians who perform therapeutic or diagnostic medical procedures involving radiation sources;

c. dentists;

d. chiropractors;

e. veterinarians;

f. medical physicists;

g radiopharmacists;

h. medical radiation technologists[56] with a diploma from a professional education institution (PEI) or a university of applied sciences (UAS);

i. medical practice assistants with a federal certificate of proficiency (CFC);

j. other medical personnel;

k. dental hygienists (PEI diploma);

l. dental assistants (CFC);

m. surgical technicians (HF diploma) and qualified operating theatre nurses with a certificate of proficiency from the Swiss Professional Association for Nurses (ASI);

n. veterinary practice assistants (CFC);

o. persons who deal in, install or maintain medical X-ray systems.

[2] The following persons, if they have completed appropriate radiological protection training regulated by the FDHA and fulfil their continuing education obligations, meet the requirements for being able to serve as radiological protection experts in their field of activity:

a. physicians and chiropractors with an appropriate Swiss specialist title;

b. dentists and veterinary surgeons with an appropriate Swiss degree;

c. medical physicists;

d. radiopharmacists;

e. medical radiation technologists[57] (PEI, UAS).

Art. 183 Categories of persons subject to mandatory training and continuing education in non-medical sectors

The requirements specified by the FDHA, in consultation with ENSI and the DDPS, for training and continuing education in radiological protection in non-medical sectors shall be differentiated according to the following categories of persons:

a. radiological protection experts and persons in the nuclear, industrial, commercial, teaching, transport and research sectors who are involved in the handling of ionising radiation;

b. radiological protection specialists, radiological protection technicians and radiological protection officers in nuclear installations and at the PSI;

c. radon consultants;

56 Footnote relevant to Swiss language texts.
57 Footnote relevant to Swiss language texts.

d. persons who, in the case of an failure or emergency, are involved in the handling of ionising radiation, may be exposed to it, or plan or order the handling thereof, or operate critical infrastructure or provide public services.

Title 6 Supervision, Enforcement and Advice

Chapter 1 Supervision

Art. 184 Supervisory authorities

1 The FOPH, Suva and ENSI are responsible for supervision in accordance with this Ordinance.

2 The FOPH shall supervise those enterprises which are not supervised by Suva or ENSI, in particular:

a. medical enterprises;

b. research and teaching establishments.

3 ENSI shall supervise:

a. nuclear installations;

b. geological investigations as specified in Article 35 of the NEA[58];

c. the receipt and shipment of radioactive substances at or from nuclear installations;

d.[59] the decay storage of radioactive waste from nuclear installations and all related activities.

4 Suva shall supervise industrial and commercial enterprises.

5 The supervisory authorities shall coordinate enforcement and resolve any uncertainties regarding responsibility by mutual agreement. They shall meet regularly for this purpose.

Art. 185 Supervisory authorities' archiving duties and duty to provide information

1 The archiving of documents concerning the granting and modification of licences and concerning supervision is governed by the Archiving Act of 26 June 1998[60].

2 The supervisory authorities shall make the required documents available to the licensing authorities at any time upon request.

58 SR **732.1**
59 Inserted by No II of the O of 7 Dec. 2018, in force since 1 Feb. 2019 (AS **2019** 183).
60 SR **152.1**

Art. 186 Research

[1] The supervisory authorities may, by mutual agreement, commission research projects concerning the effects of radiation and radiological protection, or participate in such projects.

[2] The PSI, the Spiez Laboratory and other federal establishments shall, as far as possible, place themselves at the disposal of the supervisory authorities to carry out research projects concerning the effects of radiation and radiological protection.

Chapter 2 Enforcement

Section 1 Monitoring

Art. 187 Principle

The FOPH, Suva and ENSI shall monitor by means of spot checks, graduated according to the hazard potential, whether regulations are complied with and the protection of people and the environment against dangers arising from ionising radiation is assured.

Art. 188 Cooperation duties

[1] All information must be provided and all devices, articles and documents required for inspections must be made available, at no cost, to the FOPH, Suva and ENSI.

[2] They must be granted access to installations, equipment and areas, insofar as this is necessary for conducting inspections.

Art. 189 Engagement of third parties

The FOPH may request third parties to carry out inspections, in particular:

a. firms which conduct quality assurance of diagnostic equipment;

b. experts who coordinate, prepare and conduct clinical audits.

Art. 190 Monitoring of import, export and transit

[1] In the course of import, export and transit controls, the customs offices shall check whether a licence has been obtained for the transport of radioactive material.

[2] If so requested by the licensing authority, they shall check whether goods undergoing import, export and transit comply with the provisions of this Ordinance.

[3] The FOPH shall organise the conduct of periodic targeted screening of goods undergoing import, export and transit and of persons entering the country; for this purpose, it shall consult in particular the Directorate General of Customs.

[4] It shall coordinate, in particular with the Spiez Laboratory, requirements for, and the procurement and maintenance of, the necessary measuring equipment and shall prepare deployment in special situations.

[5] It is responsible for approval of agreements concerning the possible take-back of exported radioactive waste as specified in Article 25 paragraph 3 letter d of the RPA.

6 The Directorate General of Customs, in consultation with the licensing authorities, shall issue internal directives for monitoring of the import, export and transit of radioactive material.

7 The Swiss Federal Customs Administration may, on request, transfer data from customs declarations to the licensing and supervisory authorities.

Section 2
Monitoring of Ionising Radiation and Radioactivity in the Environment

Art. 191 Responsibilities

1 The FOPH shall monitor ionising radiation and radioactivity in the environment.

2 ENSI shall additionally monitor ionising radiation and radioactivity in the vicinity of nuclear installations.

3 To assess public exposure to radioactivity in the environment, the FOPH shall carry out measurements in appropriate sampling media such as airborne particulates, water intended for human consumption, or foodstuffs. To this end, it may collaborate with the cantons.

4 To protect the health of consumers, the cantons shall monitor radioactivity in foodstuffs and in articles of daily use.

5 The FDHA, in consultation with ENSI and after a hearing with METAS, shall issue technical provisions for environmental dosimetry.

Art. 192 Automatic network for monitoring radioactivity in Switzerland

1 The FOPH shall operate an automatic network for the general monitoring of radioactivity in the environment. This network shall also measure immission levels in the vicinity of enterprises which discharge radioactive substances to the environment or could discharge larger quantities thereof.

2 The FOPH, in cooperation with the competent supervisory authority, shall specify requirements for the monitoring network with regard to monitoring in the vicinity of enterprises as specified in paragraph 1.

3 Enterprises where a substantial release of radioactivity cannot be ruled out shall bear the costs of purchasing and operating those monitoring stations within the automatic network which are used to monitor radioactivity in their vicinity.

4 The costs of purchasing equipment, excluding planning costs, are deemed to be acquisition costs. The costs of site rental, assurance of information security, maintenance and repair, and electricity are deemed to be operating costs.

5 The FOPH shall charge the previous year's costs for running the relevant monitoring stations annually to the individual enterprises.

Art. 193 Sampling and measurement programme

[1] The FOPH, in cooperation with ENSI, Suva, the NEOC and the cantons, shall prepare a sampling and measurement programme for planned and for existing exposure situations.

[2] For the implementation of the sampling and measurement programme, the federal laboratories, in particular the PSI, the Swiss Federal Institute of Aquatic Science and Technology (Eawag) and the Spiez Laboratory, are required to cooperate and to make available at all times the necessary human and material resources.

[3] Third parties may be engaged if needed to implement the sampling and measurement programme

Art. 194 Collection of data, radiological assessment and reporting

[1] ENSI, Suva, the NEOC, the cantons and the participating laboratories shall make available to the FOPH the monitoring data generated and interpreted.

[2] On the basis of the results of the sampling and measurement programme specified in Article 193, the FOPH shall assess the radiological situation. It shall calculate and assess the doses accumulated by the public. This is without prejudice, in emergency exposure situations, to the provisions of the CCMBO[61].

[3] The FOPH shall determine public radiation exposure in accordance with Annexes 3–6.

[4] It shall prepare and publish an annual report on the monitoring data and the resultant radiation doses to the public.

Art. 195 Investigation thresholds in environmental monitoring

[1] If concentrations of artificial radionuclides in the environment are detected which could lead to an effective dose of more than 10 μSv per year for a given exposure pathway and for members of the public, the FOPH shall seek to identify the cause.

[2] If the radionuclides were discharged by an enterprise which has a licence, the FOPH shall inform the supervisory authority concerned. Where possible and appropriate, this authority shall request the implementation of optimisation measures to reduce the discharge.

[3] If the radionuclides were discharged by an enterprise which does not have a licence, if the radionuclides originated abroad, or if the cause is unclear, the FOPH shall appropriately supplement its measurement programme, if necessary, and inform the public.

61 SR **520.17**

Section 3 Further Enforcement Provisions

Art. 196 Provision of information on events of public interest

The FOPH shall ensure that the persons and cantons concerned and the public are informed in a timely manner about events of public interest.

Art. 197 Monitoring of occupationally exposed aircrew

The FOCA shall supervise aircraft operators with regard to the monitoring of occupationally exposed aircrew.

Chapter 3 Federal Commission for Radiological Protection

Art. 198

[1] The KSR is a standing advisory commission within the meaning of Article 8*a* paragraph 2 of the GAOO[62].

[2] It shall advise the Federal Council, the FDHA, the DETEC, the DDPS, ENSI, interested public offices and Suva on radiological protection matters. It has the following duties:

a. regularly informing the public about the radiological protection situation in Switzerland;

b. providing advice on the following matters in particular:
   1. the interpretation and appraisal of international recommendations in the field of radiological protection with regard to their application in Switzerland,
   2. the elaboration and development of harmonised principles for the application of radiological protection regulations,
   3. environmental radioactivity, the results of monitoring, their interpretation and the resultant radiation doses for the public;

c. in collaboration with the professional and sectoral associations concerned, preparing and publishing recommendations on the justification of diagnostic or therapeutic procedures in accordance with Article 28 paragraphs 1 and 2;[63]

d preparing reports and opinions on behalf of the Federal Council or the supervisory authorities.

[3] It is composed of experts from academia and industry.

[4] It shall collaborate with the Federal Commission for NBC Protection (ComNBC) and the Federal Nuclear Safety Commission (NCS), dealing in particular with joint responsibilities in the field of radiological protection.

62 SR **172.010.1**
63 www.ksr-cpr.ch

5 The KSR and its committees may engage external experts for the examination of special issues.

Title 7 Criminal Provisions

Art. 199

1 In accordance with Article 44 paragraph 1 letter f of the RPA, an offence is committed by any person who:

a. without a licence, mixes radioactive with other materials so that the handling thereof is not subject to mandatory licensing and supervision (Art. 107);

b. performs an activity which may involve an ionising radiation hazard without having the training required in accordance with Articles 172–175;

c. operates a personal dosimetry service without approval (Art. 66);

d. operates a personal dosimetry service and contravenes the duties specified in Articles 69–71;

e. fails to include in a customs declaration the details specified in Article 103, or fails to declare or knowingly makes a false declaration in respect of radioactive goods.

2 Any person who wilfully fails to assume responsibilities imposed in accordance with Article 20 paragraph 2 letter b of the RPA is liable to a fine not exceeding 20 000 Swiss francs.

Title 8 Final Provisions

Art. 200 Repeal of other legislation

The Radiological Protection Ordinance of 22 June 1994[64] is repealed.

Art. 201 Amendments to other legislation

Amendments to other legislation are dealt with in Annex 11.

Art. 202 Transitional provisions

1 Licences granted prior to the commencement of this Ordinance shall remain valid until their renewal or expiry. The duties arising from a licence are based on the provisions of this Ordinance.

64 [AS **1994** 1947, **1995** 4959 No II 2, **1996** 2129, **2000** 107 934 2894, **2001** 3294 No II 7, **2005** 601 Annex 7 No 3 2885 Annex No 7, **2007** 1469 Annex 4 No 44 5651, **2008** 3153 Art. 10 No 2 5747 Annex No 22, **2010** 5191 Art. 20 No 4 5395 Annex 2 No II 3, **2011** 5227 No I 2.7, **2012** 7065 No I 5 7157, **2013** 3041 No I 5 3407 Annex 6 No 3]

2 Proceedings which are pending when this Ordinance comes into force are subject to the provisions of this Ordinance.

3 The limit for the equivalent dose for the lens of the eye specified in Article 56 paragraph 3 letter a applies from 1 January 2019; before that date, the limit specified in current legislation applies.

4 Article 43 (Licence holders' self-evaluation and quality manual) must be implemented no later than two years after the commencement of this Ordinance.

5 Any person who, when this Ordinance comes into force, holds a licence for a high-activity sealed source must:

a. submit to the licensing authority, no later than two years after the commencement of this Ordinance, the information specified in Article 97 for the preparation of the inventory;

b. inform the supervisory authority, no later than two years after the commencement of this Ordinance, what safety and security measures have been defined in accordance with Article 99.

6 Any person who, when this Ordinance comes into force, owns an enterprise where there is an increased likelihood of orphan radioactive materials being encountered must implement the measures specified in Article 104 no later than three years after the commencement of this Ordinance and apply for a licence for the activity.

7 Radioactive waste which, when this Ordinance comes into force, is already in storage for decay as specified in Article 117 paragraph 2 may, after a new assessment on the basis of the new clearance limits, be stored for a maximum of another 30 years. The assessment must be presented to the supervisory authority no later than two years after the commencement of this Ordinance.

8 The cantons shall modify the building permission procedure within two years after the commencement of this Ordinance in such a way that it meets the requirements specified in Article 163 paragraph 1.

9 Article 171 (Long-term contamination following an emergency) does not apply until three years after the commencement of this Ordinance.

Art. 203 Commencement

This Ordinance comes into force on 1 January 2018.

Annex 1
(Art. 2 para. 2 let. b)

Definitions of technical terms

Note

The terms are listed in alphabetical order.

Active personal dosimeter

Electronic personal dosimeter which provides a direct display of the accumulated dose as well as other dosimetric information, depending on the intended use.

Activity concentration index for building materials

The activity concentration index I is given by the following formula:

$I = C_{Ra226}/300\ Bq/kg + C_{Th232}/200\ Bq/kg + C_{K40}/3000\ Bq/kg$

where C_{Ra226}, C_{Th232} and C_{K40} are the activity concentrations in Bq/kg of the corresponding radionuclides in the building material.

Compact X-ray systems

X-ray systems with a tube voltage of up to 70 kV, a tube current of up to 15 milliamperes (mA) and a radiation field size of ≤ 6 cm diameter.

Diagnostic reference level

Dose level used for purposes of optimisation in diagnostic or interventional medical exposures, or activity level in the case of radiopharmaceuticals. Diagnostic reference levels are defined for typical examinations for groups of standard-sized patients or standard phantoms for broadly defined types of equipment.

Full protection system

Shielding of an installation or an irradiator, which ensures that useful, scattered and stray radiation is completely contained and shielded to such an extent that the ambient dose rate at a distance of 10 cm from the surface is reduced to less than 1 µSv per hour and that, at all accessible locations, the dose limits applicable for members of the public cannot be exceeded.

Interventional radiology

Diagnostic or therapeutic interventions performed under image guidance with ionising radiation. These also include interventions outside the field of radiology, e.g. in angiology, surgery, gastroenterology, cardiology, orthopaedics, pain therapy or urology.

Partial protection system

Shielding of an installation which ensures that, during operation, useful, scattered and stray radiation is completely contained, except for sample openings, and shielded to such an extent that the ambient dose rate at a distance of 10 cm from the surface is reduced to less than 1 µSv per hour and that, at all accessible locations, the dose limits applicable for members of the public cannot be exceeded.

Preparation of a radiopharmaceutical

Process in which the final radiopharmaceutical product is produced by following the radiolabelling instructions specified by the licence of a radiolabelling kit for diagnostic purposes.

Radiopharmaceuticals

Medicinal products containing radionuclides whose radiation is utilised for diagnosis or therapy. For the purposes of this Ordinance, the following are considered to be radiopharmaceuticals:

a. pharmaceuticals which, when ready for use, contain one or more radionuclides to be used for a medicinal purpose;

b. non-radioactive components (kits) used to prepare radiopharmaceuticals by reconstitution or combination with radionuclides immediately prior to use in humans;

c. radionuclide generators incorporating a fixed parent radionuclide from which is produced a daughter radionuclide which is to be obtained by elution or by any other method and used to prepare a radiopharmaceutical;

d. radionuclides used directly or as precursors for the radiolabelling of other substances (carrier compounds, cells, plasma proteins) prior to their administration.

Radon

The isotope radon-222.

Triage measurement

Procedure for detecting possible intakes without determining the effective dose. If a predefined threshold is exceeded, personal dosimetry must be performed to assess the committed effective dose.

Stray radiation sources

Equipment or devices in which only electrons are accelerated and which generate X-rays without being operated for this purpose. Electron microscopes are also considered to be stray radiation sources.

Annex 2
(Art. 2 para. 1 let. k, 10 let. f, 168 para. 2 let. a and 169 para. 1)

NORM clearance limits

NORM Clearance limits for naturally occurring radionuclides in solid materials which are in full or partial secular equilibrium with their progeny:

–	Natural radionuclides from the U-238 series	1 000 Bq/kg
–	Natural radionuclides from the Th-232 series	1 000 Bq/kg
–	K-40	10 000 Bq/kg

Annex 3[65]
(Art. 2 para. 1 let. j, l and m and Art. 194 para. 3)

Data for operational radiological protection, clearance limits, licensing limits and guidance values

Explanatory notes on the individual columns and a list of footnotes are given at the end of the table.

Radionuclide	Half-life	Type of decay/ radiation	Assessment quantities					Clearance limit		Licensing limit	Guidance values		Unstable daughter nuclide
			e_{inh} Sv/Bq	e_{ing} Sv/Bq	h_{10} (mSv/h)/ GBq at 1 m distance	$h_{0,07}$ (mSv/h)/ GBq at 10 cm distance	$h_{c,0,07}$ (mSv/h)/ (kBq/cm^2)	**LL** Bq/g		**LA** Bq	**CA** Bq/m^3	**CS** Bq/ cm^2	
1	2	3	4	5	6	7	8	9		10	11	12	13
H-3, OBT	12.32 a	β^-	4.10 E-11	4.20 E-11	<0.001	<1	<0.1	1.E+02		1.00 E+08	2.00 E+05	1000	
H-3, HTO		β^-	1.80 E-11	1.80 E-11	<0.001	<1	<0.1	1.E+02		3.00 E+08	5.00 E+05	1000	
H-3, gaz [7]		β^-	1.80 E-15		<0.001	<1	<0.1			3.00 E+12	5.00 E+09		
Be-7	53.22 d	ec / ph	4.60 E-11	2.80 E-11	0.008	<1	0.1	1.E+01		1.00 E+08	2.00 E+05	100	
Be-10	1.51 E6 a	β^-	1.90 E-08	1.10 E-09	<0.001	2000	1.6	1.E+02		3.00 E+05	4.00 E+02	3	
C-11	20.39 min	ec, β^+ / ph	3.20 E-12	2.40 E-11	0.160	1000	1.7	1.E+01	[1]	7.00E+07	7.00 E+04 [3]	3	
C-11 monoxide			1.2 E-12							7.00E+07	7.00 E+04 [3]		
C-11 dioxide			2.2 E-12							7.00E+07	7.00 E+04 [3]		
C-14	5.70 E3 a	β^-	5.80 E-10	5.80 E-10	<0.001	200	0.3	1.E+00		9.00E+06	1.00 E+04	30	
C-14 monoxide			8.00 E-13							6.00E+09	1.00 E+07		
C-14 dioxide			6.50 E-12							8.00E+08	1.00 E+06		
N-13	9.965 min	ec, β^+ / ph			0.160	1000	1.7	1.E+02	[1]	7.00E+07	7.00 E+04 [3]	3	
O-15	122.24 s	ec, β^+ / ph			0.161	1000	1.7	1.E+02	[1]	7.00E+07	7.00 E+04 [3]	3	
F-18	109.77 min	ec, β^+ / ph	9.30 E-11	4.90 E-11	0.160	2000	1.7	1.E+01	[1]	7.00E+07	7.00 E+04 [3]	3	
Na-22	2.6019 a	ec, β^+ / ph	2.00 E-09	3.20 E-09	0.330	2000	1.6	1.E-01		3.00E+06	4.00 E+03	3	
Na-24	14.9590 h	β^- / ph	5.30 E-10	4.30 E-10	0.506	1000	1.9	1.E+00		9.00E+06	2.00 E+04	3	
Mg-28 / Al-28	20.915 h	β^- / ph	1.70 E-09	2.20 E-09	0.529	2000	3.1	1.E+01	[2]	3.00E+06	5.00 E+03	3	

65 The correction of 24 April 2018 relates to the French text only (AS **2018** 1653).

Radionuclide	Half-life	Type of decay/ radiation	Assessment quantities					Clearance limit		Licensing limit	Guidance values		Unstable daughter nuclide
			e_{inh} Sv/Bq	e_{ing} Sv/Bq	h_{10} (mSv/h)/ GBq at 1 m distance	$h_{0.07}$ (mSv/h)/ GBq at 10 cm distance	$h_{c,0.07}$ (mSv/h)/ (kBq/cm^2)	**LL** Bq/g		**LA** Bq	**CA** Bq/m^3	**CS** Bq/ cm^2	
1	2	3	4	5	6	7	8	9		10	11	12	13
Al-26	7.17 E5 a	ec, β+ / ph	1.40 E-08	3.50 E-09	0.382	1000	1.5	1.E-01		4.00E+05	6.00 E+02	3	
Si-31	157.3 min	β− / ph	1.10 E-10	1.60 E-10	<0.001	1000	1.6	1.E+03		5.00E+07	8.00 E+04	3	
Si-32	132 a	β−	5.50 E-08	5.60 E-10	<0.001	500	0.6	1.E+02	[2]	9.00E+04	2.00 E+02	10	→ P-32
P-30	2.498 min	ec, β+ / ph			0.371	900	1.7					3	
P-32	14.263 d	β−	2.90E-09	2.40E-09	<0.001	1000	1.6	1.E+03		2.00E+06	3.00E+03	3	
P-33	25.34 d	β−	1.30E-09	2.40E-10	<0.001	700	0.8	1.E+03		4.00E+06	6.00E+03	10	
S-35 (inorg.)	87.51 d	β−	1.10E-09	1.90E-10	<0.001	200	0.3	1.E+02		5.00E+06	8.00E+03	30	
S-35 (org.)	87.51 d	β−	1.20E-10	7.70E-10	<0.001	200	0.3	1.E+02		4.00E+07	7.00E+04	30	
Cl-36	3.01 E5 a	β−, ec, β+ / ph	5.10E-09	9.30E-10	<0.001	1000	1.5	1.E+00		1.00E+06	2.00E+03	3	
Cl-38	37.24 min	β− / ph	7.30E-11	1.20E-10	1.551	1000	1.8	1.E+01	[1]	4.00E+07	4.00E+04	[3] 3	
Cl-39	55.6 min	β− / ph	7.60E-11	8.50E-11	0.241	1000	1.7	1.E+01	[1]	7.00E+07	1.00E+05	3	→ Ar-39
Ar-37	35.04 d	ec / ph			<0.001	<1	<0.1			6.00E+13	6.00E+10		
Ar-39	269 a	β−			<0.001	2000	1.5			6.00E+09	6.00E+06	[4]	
Ar-41	109.61 min	β− / ph			0.188	1000	1.7			5.00E+07	5.00E+04		
K-38	7.636 min	ec, β+ / ph			0.480	1000	1.8					3	
K-40 [10]	1.251 E9 a	β−, ec, β+ / ph	3.00E-09	6.20E-09	0.022	1000	1.5	1.E+00		2.00E+06	3.00E+03	3	
K-42	12.360 h	β− / ph	2.00E-10	4.30E-10	0.464	1000	1.7	1.E+02		3.00E+07	4.00E+04	3	
K-43	22.3 h	β− / ph	2.60E-10	2.50E-10	0.152	1000	1.6	1.E+01		2.00E+07	3.00E+04	3	
K-44	22.13 min	β− / ph	3.70E-11	8.40E-11	1.553	1000	1.8	1.E+01	[1]	1.00E+08	2.00E+05	3	
K-45	17.3 min	β− / ph	2.80E-11	5.40E-11	0.302	1000	1.7	1.E+01	[1]	2.00E+08	3.00E+05	3	
Ca-41	1.02 E5 a	ec / ph	1.90E-10	2.90E-10	<0.001	<1	<0.1	1.E+02		3.00E+07	4.00E+04	1000	
Ca-45	162.67 d	β−	2.30E-09	7.60E-10	<0.001	700	0.8	1.E+02	[2]	2.00E+06	4.00E+03	10	
Ca-47	4.536 d	β− / ph	2.10E-09	1.60E-09	0.156	1000	1.6	1.E+01		2.00E+06	4.00E+03	3	→ Sc-47
Sc-43	3.891 h	ec, β+ / ph	1.80E-10	1.90E-10	0.174	1000	1.4	1.E+01	[1]	3.00E+07	5.00E+04	3	
Sc-44	3.97 h	ec, β+ / ph	3.00E-10	3.50E-10	0.324	1000	1.7	1.E+01	[1]	2.00E+07	3.00E+04	3	
Sc-44m	58.61 h	it, ec / ph	2.00E-09	2.40E-09	0.045	200	0.2	1.E+01	[2]	3.00E+06	4.00E+03	30	→ Sc-44 [6]
Sc-46	83.79 d	β− / ph	4.80E-09	1.50E-09	0.299	1000	1.2	1.E-01		1.00E+06	2.00E+03	3	
Sc-47	3.3492 d	β− / ph	7.30E-10	5.40E-10	0.017	1000	1.3	1.E+02		7.00E+06	1.00E+04	3	

Radionuclide	Half-life	Type of decay/ radiation	Assessment quantities					Clearance limit		Licensing limit	Guidance values		Unstable daughter nuclide
			e_{inh} Sv/Bq	e_{ing} Sv/Bq	h_{10} (mSv/h)/ GBq at 1 m distance	$h_{0,07}$ (mSv/h)/ GBq at 10 cm distance	$h_{c,0,07}$ (mSv/h)/ (kBq/cm^2)	LL Bq/g		LA Bq	CA Bq/m^3	CS Bq/ cm^2	
1	2	3	4	5	6	7	8	9		10	11	12	13
Sc-48	43.67 h	β$^-$ / ph	1.60E-09	1.70E-09	0.495	2000	1.7	1.E+00		3.00E+06	5.00E+03	3	
Sc-49	57.2 min	β$^-$ / ph	6.10E-11	8.20E-11	0.001	1000	1.6	1.E+03	[1]	8.00E+07	1.00E+05	3	
Ti-44	60.0 a	ec / ph	7.20E-08	5.80E-09	0.026	2	<0.1	1.E-01	[2]	7.00E+04	1.00E+02	30	→ Sc-44 [6]
Ti-45	184.8 min	ec, β$^+$ / ph	1.50E-10	1.50E-10	0.136	1000	1.5	1.E+01	[1]	3.00E+07	6.00E+04	3	
V-47	32.6 min	ec, β$^+$ / ph	5.00E-11	6.30E-11	0.156	1000	1.7	1.E+01	[1]	1.00E+08	2.00E+05	3	
V-48	15.9735 d	ec, β$^+$ / ph	2.70E-09	2.00E-09	0.432	900	1	1.E+00		2.00E+06	3.00E+03	10	
V-49	330 d	ec / ph	2.60E-11	1.80E-11	<0.001	<1	<0.1	1.E+04		2.00E+08	3.00E+05	1000	
Cr-48	21.56 h	ec, β$^+$ / ph	2.50E-10	2.00E-10	0.071	50	0.1	1.E+01		2.00E+07	3.00E+04	100	→ V-48 [6]
Cr-49	42.3 min	ec, β$^+$ / ph	5.90E-11	6.10E-11	0.166	1000	1.7	1.E+01	[1]	8.00E+07	1.00E+05	3	→ V-49
Cr-51	27.7025 d	ec / ph	3.60E-11	3.80E-11	0.005	3	<0.1	1.E+02		1.00E+08	2.00E+05	1000	
Mn-51	46.2 min	ec, β$^+$ / ph	6.80E-11	9.30E-11	0.159	1000	1.7	1.E+01	[1]	7.00E+07	1.00E+05	3	→ Cr-51
Mn-52	5.591 d	ec, β$^+$ / ph	1.80E-09	1.80E-09	0.510	600	0.7	1.E+00		3.00E+06	5.00E+03	10	
Mn-52m	21.1 min	ec, β$^+$, it / ph	5.00E-11	6.90E-11	0.389	1000	1.7	1.E+01	[1]	1.00E+08	2.00E+05	3	→ Mn-52
Mn-53	3.7 E6 a	ec / ph	3.60E-11	3.00E-11	<0.001	20	<0.1	1.E+02		1.00E+08	2.00E+05	1000	
Mn-54	312.12 d	ec, β$^+$, β$^-$ / ph	1.20E-09	7.10E-10	0.126	10	0.1	1.E-01		4.00E+06	7.00E+03	100	
Mn-56	2.5789 h	β$^-$ / ph	2.00E-10	2.50E-10	0.275	1000	1.7	1.E+01	[1]	3.00E+07	4.00E+04	3	
Fe-52	8.275 h	ec, β$^+$ / ph	9.50E-10	1.40E-09	0.116	900	1	1.E+01	[2]	5.00E+06	9.00E+03	10	→ Mn-52m [6]
Fe-55	2.737 a	ec / ph	9.20E-10	3.30E-10	<0.001	20	<0.1	1.E+03		5.00E+06	9.00E+03	1000	
Fe-59	44.495 d	β$^-$ / ph	3.20E-09	1.80E-09	0.175	1000	1.1	1.E+00		2.00E+06	3.00E+03	3	
Fe-60	1.5 E6 a	β$^-$	3.30E-07	1.10E-07	<0.001	90	0.3	1.E+01		2.00E+04	3.00E+01	3	→ Co-60m [10]
Co-55	17.53 h	ec, β$^+$ / ph	8.30E-10	1.10E-09	0.302	1000	1.4	1.E+01		6.00E+06	1.00E+04	3	→ Fe-55
Co-56	77.23 d	ec, β$^+$ / ph	4.90E-09	2.50E-09	0.485	300	0.6	1.E-01		1.00E+06	2.00E+03	10	
Co-57	271.74 d	ec / ph	6.00E-10	2.10E-10	0.021	100	0.1	1.E+00		8.00E+06	1.00E+04	100	
Co-58	70.86 d	ec, β$^+$ / ph	1.70E-09	7.40E-10	0.147	300	0.3	1.E+00		3.00E+06	5.00E+03	30	
Co-58m	9.04 h	it / ph	1.70E-11	2.40E-11	<0.001	10	<0.1	1.E+04		3.00E+08	5.00E+05	1000	→ Co-58 [6]
Co-60	5.2713 a	β$^-$ / ph	1.70E-08	3.40E-09	0.366	1000	1.1	1.E-01		3.00E+05	5.00E+02	3	

Radionuclide	Half-life	Type of decay/ radiation	Assessment quantities					Clearance limit		Licensing limit	Guidance values		Unstable daughter nuclide
			e_{inh} Sv/Bq	e_{ing} Sv/Bq	h_{10} (mSv/h)/ GBq at 1 m distance	$h_{0.07}$ (mSv/h)/ GBq at 10 cm distance	$h_{c,0.07}$ (mSv/h)/ (kBq/cm^2)	**LL** Bq/g		**LA** Bq	**CA** Bq/m^3	**CS** Bq/ cm^2	
1	2	3	4	5	6	7	8	9		10	11	12	13
Co-60m	10.467 min	it, β⁻ / ph	1.20E-12	1.70E-12	0.001	20	<0.1	1.E+03		4.00E+09	7.00E+06	1000	→ Co-60 [6]
Co-61	1.650 h	β⁻ / ph	7.50E-11	7.40E-11	0.017	1000	1.6	1.E+02	[1]	7.00E+07	1.00E+05	3	
Co-62m	13.91 min	β⁻ / ph	3.70E-11	4.70E-11	0.436	1000	1.8	1.E+01	[1]	1.00E+08	2.00E+05	3	
Ni-56	6.075 d	ec, β⁺ / ph	9.60E-10	8.60E-10	0.260	60	0.1	1.E+01		5.00E+06	9.00E+03	100	→ Co-56 [6]
Ni-57	35.60 h	ec, β⁺ / ph	7.60E-10	8.70E-10	0.278	700	0.8	1.E+01		7.00E+06	1.00E+04	10	→ Co-57
Ni-59	1.01 E5 a	ec, β⁺ / ph	2.20E-10	6.30E-11	<0.001	10	<0.1	1.E+02		2.00E+07	4.00E+04	1000	
Ni-63	100.1 a	β⁻	5.20E-10	1.50E-10	<0.001	<1	<0.1	1.E+02		1.00E+07	2.00E+04	1000	
Ni-65	2.51719 h	β⁻ / ph	1.30E-10	1.80E-10	0.081	1000	1.6	1.E+01	[1]	4.00E+07	6.00E+04	3	
Ni-66 / Cu-66	54.6 h	β⁻ / ph	1.90E-09	3.00E-09	0.039	2000	2.2	1.E+03	[2]	3.00E+06	4.00E+03	3	
Cu-60	23.7 min	ec, β⁺ / ph	6.20E-11	7.00E-11	0.596	1000	1.8	1.E+01	[1]	8.00E+07	1.00E+05	3	
Cu-61	3.333 h	ec, β⁺ / ph	1.20E-10	1.20E-10	0.128	900	1.1	1.E+01	[1]	4.00E+07	7.00E+04	3	
Cu-64	12.700 h	ec, β⁺, β⁻ / ph	1.50E-10	1.20E-10	0.030	900	0.8	1.E+02		3.00E+07	6.00E+04	10	
Cu-67	61.83 h	β⁻ / ph	5.80E-10	3.40E-10	0.018	1000	1.4	1.E+02		9.00E+06	1.00E+04	3	
Zn-62 / Cu-62	9.186 h	ec, β⁺ / ph	6.60E-10	9.40E-10	0.319	1000	1.9	1.E+02	[2]	8.00E+06	1.00E+04	3	
Zn-63	38.47 min	ec, β⁺ / ph	6.10E-11	7.90E-11	0.175	1000	1.6	1.E+01	[1]	8.00E+07	1.00E+05	3	
Zn-65	244.06 d	ec, β⁺ / ph	2.80E-09	3.90E-09	0.086	40	0.1	1.E-01		2.00E+06	3.00E+03	100	
Zn-69	56.4 min	β⁻	4.30E-11	3.10E-11	<0.001	1000	1.6	1.E+03		1.00E+08	2.00E+05	3	
Zn-69m	13.76 h	it, β⁻/ ph	3.30E-10	3.30E-10	0.067	70	0.1	1.E+01	[2]	2.00E+07	3.00E+04	100	→ Zn-69
Zn-71m	3.96 h	β⁻/ ph	2.40E-10	2.40E-10	0.240	1000	1.7	1.E+01	[1]	2.00E+07	3.00E+04	3	
Zn-72	46.5 h	β⁻/ ph	1.50E-09	1.40E-09	0.026	900	0.9	1.E+00	[2]	3.00E+06	6.00E+03	10	→ Ga-72 [6]
Ga-65	15.2 min	ec, β⁺ / ph	2.90E-11	3.70E-11	0.183	1000	1.6	1.E+01	[1]	2.00E+08	3.00E+05	3	→ Zn-65
Ga-66	9.49 h	ec, β⁺ / ph	7.10E-10	1.20E-09	0.877	600	1.1	1.E+01		7.00E+06	1.00E+04	3	
Ga-67	3.2612 d	ec / ph	2.80E-10	1.90E-10	0.025	30	0.3	1.E+02		2.00E+07	3.00E+04	30	
Ga-68	67.71 min	ec, β⁺ / ph	8.10E-11	1.00E-10	0.149	1000	1.5	1.E+01	[1]	6.00E+07	1.00E+05	3	
Ga-70	21.14 min	β⁻, ec / ph	2.60E-11	3.10E-11	0.001	1000	1.6	1.E+02	[1]	2.00E+08	3.00E+05	3	
Ga-72	14.10 h	β⁻ / ph	8.40E-10	1.10E-09	0.386	1000	1.7	1.E+01		6.00E+06	1.00E+04	3	
Ga-73	4.86 h	β⁻ / ph	2.00E-10	2.60E-10	0.052	1000	1.6	1.E+02	[1]	3.00E+07	4.00E+04	3	
Ge-66	2.26 h	ec, β⁺ / ph	1.30E-10	1.00E-10	0.108	400	0.5	1.E+01	[1]	4.00E+07	6.00E+04	10	→ Ga-66 [6]

Radionuclide	Half-life	Type of decay/ radiation	Assessment quantities					Clearance limit		Licensing limit	Guidance values		Unstable daughter nuclide
			e_{inh} Sv/Bq	e_{ing} Sv/Bq	h_{10} (mSv/h)/ GBq at 1 m distance	$h_{0,07}$ (mSv/h)/ GBq at 10 cm distance	$h_{c,0,07}$ (mSv/h)/ (kBq/cm^2)	**LL** Bq/g		**LA** Bq	**CA** Bq/m^3	**CS** Bq/ cm^2	
1	2	3	4	5	6	7	8	9		10	11	12	13
Ge-67	18.9 min	ec, β^+ / ph	4.20E-11	6.50E-11	0.407	1000	1.7	1.E+01	[1]	1.00E+08	2.00E+05	3	→ Ga-67
Ge-68	270.95 d	ec / ph	7.90E-09	1.30E-09	<0.001	10	<0.1	1.E+01	[2]	6.00E+05	1.00E+03	300	→ Ga-68 [6]
Ge-69	39.05 h	ec, β^+ / ph	3.70E-10	2.40E-10	0.132	500	0.6	1.E+01		1.00E+07	2.00E+04	10	
Ge-71	11.43 d	ec / ph	1.10E-11	1.20E-11	<0.001	10	<0.1	1.E+04	[1]	5.00E+08	8.00E+05	1000	
Ge-75	82.78 min	β^- / ph	5.40E-11	4.60E-11	0.006	1000	1.6	1.E+03		9.00E+07	2.00E+05	3	
Ge-77	11.30 h	β^- / ph	4.50E-10	3.30E-10	0.163	1000	1.6	1.E+01		1.00E+07	2.00E+04	3	
Ge-78	88 min	β^- / ph	1.40E-10	1.20E-10	0.045	1000	1.5	1.E+02	[1]	4.00E+07	6.00E+04	3	→ As-78 [6]
As-69	15.23 min	ec, β^+ / ph	3.50E-11	5.70E-11	0.250	900	1.7	1.E+01	[1]	1.00E+08	2.00E+05	3	→ Ge-69
As-70	52.6 min	ec, β^+ / ph	1.20E-10	1.30E-10	0.603	1000	1.7	1.E+01	[1]	4.00E+07	7.00E+04	3	
As-71	65.28 h	ec, β^+ / ph	5.00E-10	4.60E-10	0.088	700	0.7	1.E+01		1.00E+07	2.00E+04	10	→ Ge-71
As-72	26.0 h	ec, β^+ / ph	1.30E-09	1.80E-09	0.339	900	1.6	1.E+01		4.00E+06	6.00E+03	3	
As-73	80.30 d	ec / ph	6.50E-10	2.60E-10	0.003	20	<0.1	1.E+03	[2]	8.00E+06	1.00E+04	1000	
As-74	17.77 d	ec, β^+, β^- / ph	1.80E-09	1.30E-09	0.117	900	1.1	1.E+01		3.00E+06	5.00E+03	3	
As-76	1.0778 d	β^- / ph	9.20E-10	1.60E-09	0.132	1000	1.6	1.E+01		5.00E+06	9.00E+03	3	
As-77	38.83 h	β^- / ph	4.20E-10	4.00E-10	0.001	1000	1.5	1.E+03		1.00E+07	2.00E+04	3	
As-78	90.7 min	β^- / ph	1.40E-10	2.10E-10	0.804	1000	1.7	1.E+01	[1]	4.00E+07	6.00E+04	3	
Se-70	41.1 min	ec, β^+ / ph	1.20E-10	1.40E-10	0.158	900	1.3	1.E+01	[1]	4.00E+07	7.00E+04	3	→ As-70 [6]
Se-73	7.15 h	ec, β^+ / ph	2.40E-10	3.90E-10	0.174	900	1.2	1.E+01	[1]	2.00E+07	3.00E+04	3	→ As-73
Se-73m	39.8 min	it, ec, β^+ / ph	2.70E-11	4.10E-11	0.038	300	0.4	1.E+02	[1]	2.00E+08	3.00E+05	10	→ Se-73
Se-75	119.779 d	ec / ph	1.70E-09	2.60E-09	0.064	80	0.1	1.E+00		3.00E+06	5.00E+03	100	
Se-79	2.95 E5 a	β^-	3.10E-09	2.90E-09	<0.001	200	0.4	1.E-01		2.00E+06	3.00E+03	10	
Se-81	18.45 min	β^- / ph	2.40E-11	2.70E-11	0.002	1000	1.6	1.E+03	[1]	2.00E+08	3.00E+05	3	
Se-81m	57.28 min	it, β^-	6.80E-11	5.90E-11	0.004	100	1.1	1.E+03	[1]	7.00E+07	1.00E+05	3	→ Se-81
Se-83	22.3 min	β^- / ph	5.30E-11	5.10E-11	0.362	1000	1.7	1.E+01	[1]	9.00E+07	2.00E+05	3	→ Br-83
Br-74	25.4 min	ec, β^+ / ph	6.80E-11	8.40E-11	1.022	1000	1.8	1.E+01	[1]	7.00E+07	1.00E+05	3	
Br-74m	46 min	ec, β^+ / ph	1.10E-10	1.40E-10	1.347	900	1.8	1.E+01	[1]	5.00E+07	8.00E+04	3	
Br-75	96.7 min	ec, β^+ / ph	8.50E-11	7.90E-11	0.189	900	1.3	1.E+01	[1]	6.00E+07	1.00E+05	3	→ Se-75
Br-76	16.2 h	ec, β^+ / ph	5.80E-10	4.60E-10	0.503	700	1.1	1.E+01		9.00E+06	1.00E+04	3	

Radionuclide	Half-life	Type of decay/ radiation	Assessment quantities					Clearance limit		Licensing limit	Guidance values		Unstable daughter nuclide
			e_{inh} Sv/Bq	e_{ing} Sv/Bq	h_{10} (mSv/h)/ GBq at 1 m distance	$h_{0.07}$ (mSv/h)/ GBq at 10 cm distance	$h_{c,0.07}$ (mSv/h)/ (kBq/cm^2)	**LL** Bq/g		**LA** Bq	**CA** Bq/m^3	**CS** Bq/ cm^2	
1	2	3	4	5	6	7	8	9		10	11	12	13
Br-77	57.036 h	ec, β^+ / ph	1.30E-10	9.60E-11	0.051	60	0.1	1.E+01		4.00E+07	6.00E+04	100	
Br-80	17.68 min	β^-, ec, β^+ / ph	1.70E-11	3.10E-11	0.013	1000	1.5	1.E+02	[1]	3.00E+08	5.00E+05	3	
Br-80m	4.4205 h	it / ph	1.00E-10	1.10E-10	0.012	10	<0.1	1.E+03	[2]	5.00E+07	8.00E+04	1000	→ Br-80
Br-82	35.30 h	β^- / ph	8.80E-10	5.40E-10	0.395	1000	1.4	1.E+00		6.00E+06	9.00E+03	3	
Br-83	2.40 h	β^- / ph	6.70E-11	4.30E-11	0.001	1000	1.5	1.E+03	[2]	7.00E+07	1.00E+05	3	
Br-84	31.80 min	β^- / ph	6.20E-11	8.80E-11	0.923	1000	1.7	1.E+01	[1]	8.00E+07	1.00E+05	3	
Kr-79	35.04 h	ec, β^+ / ph			0.042	100	0.2			2.00E+08	2.00E+05		
Kr-81	2.29 E5 a	ec / ph			0.004	8	<0.1			1.00E+10	1.00E+07		
Kr-83m	1.83 h	it / ph			0.002	3	<0.1			1.00E+12	1.00E+09		
Kr-85	10.756 a	β^- / ph			0.001	1000	1.5			5.00E+07 [8]	5.00E+06	[4]	
Kr-85m	4.480 h	β^-, it / ph			0.026	1000	1.4			4.00E+08	4.00E+05		→ Kr-85
Kr-87	76.3 min	β^- / ph			0.501	1000	1.7			7.00E+07	7.00E+04		→ Rb-87
Kr-88	2.84 h	β^- / ph			0.264	1000	1.5			2.00E+07	2.00E+04	[5]	→ Rb-88 [6]
Kr-89	3.15 min	β^- / ph			2.047	900	1.8			3.00E+07	3.00E+04		→ Rb-89 [6]
Rb-79	22.9 min	ec, β^+ / ph	3.00E-11	5.00E-11	0.217	2000	2.1	1.E+01	[1]	2.00E+08	3.00E+05	3	→ Kr-79
Rb-81	4.576 h	ec, β^+ / ph	6.80E-11	5.40E-11	0.101	1000	1.2	1.E+01	[1]	7.00E+07	1.00E+05	3	→ Kr-81
Rb-81m	30.5 min	it, ec, β^+ / ph	1.30E-11	9.70E-12	0.006	5	0.3	1.E+03	[1]	4.00E+08	6.00E+05	30	→ Rb-81 [6]
Rb-82m	6.472 h	ec, β^+ / ph	2.20E-10	1.30E-10	0.436	400	0.6	1.E+01		2.00E+07	4.00E+04	10	
Rb-83	86.2 d	ec / ph	1.00E-09	1.90E-09	0.082	20	<0.1	1.E+00	[2]	5.00E+06	8.00E+03	100	
Rb-84	32.77 d	ec, β^+, β^- / ph	1.50E-09	2.80E-09	0.141	400	0.6	1.E+00		3.00E+06	6.00E+03	10	
Rb-86	18.642 d	β^-, ec / ph	1.30E-09	2.80E-09	0.014	1000	1.6	1.E+02		4.00E+06	6.00E+03	3	
Rb-87	4.923 E10 a	β^-	7.60E-10	1.50E-09	<0.001	1000	1.2	1.E+01		7.00E+06	1.00E+04	3	
Rb-88	17.78 min	β^- / ph	2.80E-11	9.00E-11	2.314	900	1.7	1.E+02	[1]	2.00E+08	3.00E+05	3	
Rb-89	15.15 min	β^- / ph	2.50E-11	4.70E-11	0.659	1000	1.8	1.E+02	[1]	2.00E+08	3.00E+05	3	→ Sr-89
Sr-80 / Rb-80	106.3 min	ec, β^+ / ph	2.10E-10	3.50E-10	1.750	900	1.7	1.E+03	[2]	2.00E+07	4.00E+04	3	
Sr-81	22.3 min	ec, β^+ / ph	6.10E-11	7.80E-11	0.247	1000	1.6	1.E+01	[1]	8.00E+07	1.00E+05	3	→ Rb-81 [6]
Sr-82 / Rb-82	25.36 d	ec / ph	7.70E-09	6.10E-09	0.434	900	1.6	1.E+01	[1]	6.00E+05	1.00E+03	3	

Radionuclide	Half-life	Type of decay/ radiation	Assessment quantities					Clearance limit		Licensing limit	Guidance values		Unstable daughter nuclide
			e_{inh} Sv/Bq	e_{ing} Sv/Bq	h_{10} (mSv/h)/ GBq at 1 m distance	$h_{0,07}$ (mSv/h)/ GBq at 10 cm distance	$h_{c,0,07}$ (mSv/h)/ (kBq/cm^2)	**LL** Bq/g		**LA** Bq	**CA** Bq/m^3	**CS** Bq/ cm^2	
1	2	3	4	5	6	7	8	9		10	11	12	13
Sr-83	32.41 h	ec, β^+ / ph	4.90E-10	5.80E-10	0.127	400	0.5	1.E+01		1.00E+07	2.00E+04	10	→ Rb-83
Sr-85	64.84 d	ec / ph	6.40E-10	5.60E-10	0.086	20	0.1	1.E+00		8.00E+06	1.00E+04	100	
Sr-85m	67.63 min	it, ec, β^+ / ph	7.40E-12	6.10E-12	0.035	70	0.1	1.E+02	[1]	7.00E+08	1.00E+06	100	→ Sr-85
Sr-87m	2.815 h	it, ec / ph	3.50E-11	3.30E-11	0.053	300	0.3	1.E+02	[1]	1.00E+08	2.00E+05	30	→ Rb-87
Sr-89	50.53 d	β^-	5.60E-09	2.60E-09	<0.001	1000	1.6	1.E+03	[2]	9.00E+05	1.00E+03	3	
Sr-90	28.79 a	β^-	7.70E-08	2.80E-08	<0.001	1000	1.4	1.E+00	[2]	6.00E+04	1.00E+02	3	→ Y-90 [6]
Sr-91	9.63 h	β^- / ph	5.70E-10	7.60E-10	0.117	1000	1.6	1.E+01	[2]	9.00E+06	1.00E+04	3	→ Y-91m, Y-91
Sr-92	2.66 h	β^- / ph	3.40E-10	4.90E-10	0.194	1000	1.4	1.E+01	[1]	1.00E+07	2.00E+04	3	→ Y-92 [6]
Y-86	14.74 h	ec, β^+ / ph	8.10E-10	9.60E-10	0.515	500	0.8	1.E+00		6.00E+06	1.00E+04	10	
Y-86m	48 min	it, ec, β^+ / ph	4.90E-11	5.60E-11	0.034	200	0.1	1.E+02	[1]	1.00E+08	2.00E+05	100	→ Y-86 [6]
Y-87	79.8 h	ec, β^+ / ph	5.30E-10	5.50E-10	0.080	20	<0.1	1.E+01	[2]	9.00E+06	2.00E+04	300	
Y-88	106.65 d	ec, β+ / ph	3.30E-09	1.30E-09	0.380	40	0.2	1.E-01		2.00E+06	3.00E+03	30	
Y-90	64.10 h	β^-	1.70E-09	2.70E-09	0.007	1000	1.6	1.E+03		3.00E+06	5.00E+03	3	
Y-90m	3.19 h	it, β^- / ph	1.30E-10	1.70E-10	0.098	200	0.2	1.E+01	[1]	4.00E+07	6.00E+04	30	→ Y-90
Y-91	58.51 d	β^- / ph	6.10E-09	2.40E-09	0.001	1000	1.6	1.E+02		8.00E+05	1.00E+03	3	
Y-91m	49.71 min	it / ph	1.50E-11	1.10E-11	0.082	70	0.1	1.E+02	[1]	3.00E+08	6.00E+05	100	→ Y-91
Y-92	3.54 h	β^- / ph	2.80E-10	4.90E-10	0.546	1000	1.7	1.E+02		2.00E+07	3.00E+04	3	
Y-93	10.18 h	β^- / ph	6.00E-10	1.20E-09	0.098	1000	1.6	1.E+02		8.00E+06	1.00E+04	3	→ Zr-93
Y-94	18.7 min	β^- / ph	4.60E-11	8.10E-11	1.111	900	1.7	1.E+01	[1]	1.00E+08	2.00E+05	3	
Y-95	10.3 min	β^- / ph	2.60E-11	4.60E-11	1.219	1000	1.7	1.E+01	[1]	2.00E+08	3.00E+05	3	→ Zr-95 [6]
Zr-86	16.5 h	ec, β^+ / ph	7.00E-10	8.60E-10	0.069	100	0.1	1.E+01	[2]	7.00E+06	1.00E+04	100	→ Y-86 [6]
Zr-88	83.4 d	ec / ph	4.10E-09	3.30E-10	0.076	50	0.1	1.E+00		1.00E+06	2.00E+03	100	→ Y-88 [6]
Zr-89	78.41 h	ec, β^+ / ph	7.50E-10	7.90E-10	0.182	400	0.5	1.E+01	[1]	7.00E+06	1.00E+04	10	
Zr-93	1.53 E6 a	β^-	2.90E-08	2.80E-10	<0.001	<1	<0.1	1.E+01		2.00E+05	3.00E+02	1000	→ Nb-93m
Zr-95	64.032 d	β^- / ph	4.20E-09	8.80E-10	0.112	1000	1.1	1.E+00	[2]	1.00E+06	2.00E+03	3	→ Nb-95 [6]
Zr-97	16.744 h	β^- / ph	1.40E-09	2.10E-09	0.027	1000	1.6	1.E+01	[2]	4.00E+06	6.00E+03	3	→ Nb-97
Nb-88	14.5 min	ec, β^+ / ph	5.00E-11	6.30E-11	0.719	1000	1.8	1.E+01	[1]	1.00E+08	2.00E+05	3	→ Zr-88

Radionuclide	Half-life	Type of decay/ radiation	Assessment quantities					Clearance limit		Licensing limit	Guidance values		Unstable daughter nuclide
			e_{inh} Sv/Bq	e_{ing} Sv/Bq	h_{10} (mSv/h)/ GBq at 1 m distance	$h_{0.07}$ (mSv/h)/ GBq at 10 cm distance	$h_{c,0.07}$ (mSv/h)/ (kBq/cm^2)	**LL** Bq/g		**LA** Bq	**CA** Bq/m^3	**CS** Bq/ cm^2	
1	2	3	4	5	6	7	8	9		10	11	12	13
Nb-89	2.03 h	ec, β$^+$ / ph	1.90E-10	3.00E-10	0.392	700	1.3	1.E+01	[1]	3.00E+07	4.00E+04	3	→ Zr-89
Nb-89m	66 min	ec, β$^+$ / ph	1.20E-10	1.40E-10	0.306	900	1.5	1.E+01	[1]	4.00E+07	7.00E+04	3	→ Zr-89
Nb-90	14.60 h	ec, β$^+$ / ph	1.10E-09	1.20E-09	0.574	2000	1.9	1.E+01	[1]	5.00E+06	8.00E+03	3	
Nb-91	680 a	ec, β$^+$ / ph						1.E+02		1.00E+06	2.00E+03	1000	
Nb-91m	60.86 d	it, ec, β$^+$ / ph						1.E+01		2.00E+06	4.00E+03	300	
Nb-92m	10.15 d	ec, β$^+$ / ph						1.E+01		8.00E+06	1.00E+04	300	
Nb-93m	16.13 a	it / ph	8.60E-10	1.20E-10	0.003	<1	<0.1	1.E+01		6.00E+06	1.00E+04	1000	
Nb-94	2.03 E4 a	β$^-$ / ph	2.50E-08	1.70E-09	0.237	1000	1.5	1.E-01		2.00E+05	3.00E+02	3	
Nb-95	34.991 d	β$^-$ / ph	1.30E-09	5.80E-10	0.116	100	0.3	1.E+00		4.00E+06	6.00E+03	30	
Nb-95m	3.61 d	it, β$^-$ / ph	8.50E-10	5.60E-10	0.021	2000	1.4	1.E+02		6.00E+06	1.00E+04	3	→ Nb-95 [6]
Nb-96	23.35 h	β$^-$ / ph	9.70E-10	1.10E-09	0.372	1000	1.6	1.E+00		5.00E+06	9.00E+03	3	
Nb-97	72.1 min	β$^-$ / ph	7.20E-11	6.80E-11	0.099	1000	1.6	1.E+01	[1]	7.00E+07	1.00E+05	3	
Nb-98m	51.3 min	β$^-$ / ph	9.90E-11	1.10E-10	0.393	1000	1.8	1.E+01	[1]	5.00E+07	8.00E+04	3	
Mo-90	5.56 h	ec, β$^+$ / ph	5.60E-10	6.20E-10	0.147	1000	1.4	1.E+01	[1]	9.00E+06	1.00E+04	3	→ Nb-90 [6]
Mo-93	4.0 E3 a	ec / ph	1.40E-09	2.60E-09	0.016	4	<0.1	1.E+01		4.00E+06	6.00E+03	100	
Mo-93m	6.85 h	it, ec / ph	3.00E-10	2.80E-10	0.330	800	0.8	1.E+01		2.00E+07	3.00E+04	10	→ Mo-93
Mo-99	65.94 h	β$^-$ / ph	1.10E-09	1.20E-09	0.024	1000	1.6	1.E+01	[2]	5.00E+06	8.00E+03	3	→ Tc-99m, Tc-99
Mo-101	14.61 min	β$^-$ / ph	4.50E-11	4.20E-11	0.196	1000	1.7	1.E+01	[1]	1.00E+08	2.00E+05	3	→ Tc-101
Tc-93	2.75 h	ec, β$^+$ / ph	6.50E-11	4.90E-11	0.222	20	0.1	1.E+01	[1]	8.00E+07	1.00E+05	100	→ Mo-93
Tc-93m	43.5 min	it, ec, β$^+$ / ph	3.10E-11	2.40E-11	0.098	300	0.4	1.E+01	[1]	2.00E+08	3.00E+05	10	→ Tc-93, Mo-93
Tc-94	293 min	ec, β$^+$ / ph	2.20E-10	1.80E-10	0.414	200	0.4	1.E+01	[1]	2.00E+07	4.00E+04	10	
Tc-94m	52.0 min	ec, β$^+$ / ph	8.00E-11	1.10E-10	0.285	700	1.3	1.E+01	[1]	6.00E+07	1.00E+05	3	
Tc-95	20.0 h	ec / ph	1.80E-10	1.60E-10	0.135	20	0.1	1.E+01		3.00E+07	5.00E+04	100	
Tc-95m	61 d	ec, β$^+$, it / ph	8.60E-10	6.20E-10	0.117	100	0.1	1.E+00	[2]	6.00E+06	1.00E+04	100	→ Tc-95
Tc-96	4.28 d	ec / ph	1.00E-09	1.10E-09	0.388	40	0.2	1.E+00		5.00E+06	8.00E+03	30	
Tc-96m	51.5 min	it, ec, β$^+$ / ph	1.10E-11	1.30E-11	0.016	3	<0.1	1.E+03	[1]	5.00E+08	8.00E+05	1000	→ Tc-96

Radionuclide	Half-life	Type of decay/ radiation	Assessment quantities					Clearance limit	Licensing limit	Guidance values		Unstable daughter nuclide
			e_{inh} Sv/Bq	e_{ing} Sv/Bq	h_{10} (mSv/h)/ GBq at 1 m distance	$h_{0,07}$ (mSv/h)/ GBq at 10 cm distance	$h_{c,0,07}$ (mSv/h)/ (kBq/cm^2)	**LL** Bq/g	**LA** Bq	**CA** Bq/m^3	**CS** Bq/ cm^2	
1	2	3	4	5	6	7	8	9	10	11	12	13
Tc-97	2.6 E6 a	ec / ph	1.60E-10	8.30E-11	0.017	4	<0.1	1.E+01	3.00E+07	5.00E+04	1000	
Tc-97m	90.1 d	it / ph	2.70E-09	6.60E-10	0.014	30	0.7	1.E+02	2.00E+06	3.00E+03	10	→ Tc-97
Tc-98	4.2 E6 a	β$^-$ / ph	6.10E-09	2.30E-09	0.215	2000	1.5	1.E-01	8.00E+05	1.00E+03	3	
Tc-99	2.111 E5 a	β$^-$	3.20E-09	7.80E-10	<0.001	1000	1.1	1.E+00	2.00E+06	3.00E+03	3	
Tc-99m	6.015 h	it, β$^-$/ ph	2.90E-11	2.20E-11	0.022	300	0.2	1.E+02 [1]	2.00E+08	3.00E+05	30	→ Tc-99
Tc-101	14.2 min	β$^-$ / ph	2.10E-11	1.90E-11	0.055	1000	1.6	1.E+02 [1]	2.00E+08	4.00E+05	3	
Tc-104	18.3 min	β$^-$ / ph	4.80E-11	8.10E-11	1.219	1000	1.8	1.E+01 [1]	1.00E+08	2.00E+05	3	
Ru-94	51.8 min	ec, β$^+$ / ph	7.40E-11	9.40E-11	0.100	20	0.1	1.E+02 [1]	7.00E+07	1.00E+05	100	→ Tc-94
Ru-97	2.9 d	ec / ph	1.60E-10	1.50E-10	0.055	100	0.1	1.E+01	3.00E+07	5.00E+04	100	→ Tc-97
Ru-103	39.26 d	β$^-$ / ph	2.20E-09	7.30E-10	0.073	500	0.6	1.E+00 [2]	2.00E+06	4.00E+03	10	
Ru-105	4.44 h	β$^-$ / ph	2.50E-10	2.60E-10	0.119	1000	1.6	1.E+01 [1]	2.00E+07	3.00E+04	3	→ Rh-105
Ru-106 / Rh-106	373.59 d	β$^-$ / ph	3.50E-08	7.00E-09	0.357	1000	1.6	1.E-01 [2]	1.00E+05	2.00E+02	3	
Rh-99	16.1 d	ec, β$^+$ / ph	8.90E-10	5.10E-10	0.115	100	0.2	1.E+01 [1]	6.00E+06	9.00E+03	30	
Rh-99m	4.7 h	ec, β$^+$ / ph	7.30E-11	6.60E-11	0.122	100	0.2	1.E+01 [1]	7.00E+07	1.00E+05	30	
Rh-100	20.8 h	ec, β$^+$ / ph	6.30E-10	7.10E-10	0.392	100	0.3	1.E+00	8.00E+06	1.00E+04	30	
Rh-101	3.3 a	ec / ph	3.10E-09	5.50E-10	0.062	300	0.4	1.E+00	2.00E+06	3.00E+03	10	
Rh-101m	4.34 d	ec,it / ph	2.70E-10	2.20E-10	0.066	200	0.2	1.E+01	2.00E+07	3.00E+04	30	→ Rh-101
Rh-102	207 d	ec, β$^+$, β$^-$ / ph	4.20E-09	1.20E-09	0.085	400	0.6	1.E-01	1.00E+06	2.00E+03	10	
Rh-102m	3.742 a	ec, β$^+$, it / ph	9.00E-09	2.60E-09	0.339	50	0.2	1.E+00	6.00E+05	9.00E+02	30	→ Rh-102
Rh-103m	56.114 min	it / ph	2.50E-12	3.80E-12	0.002	<1	<0.1	1.E+04 [1]	2.00E+09	3.00E+06	1000	
Rh-105	35.36 h	β$^-$ / ph	4.40E-10	3.70E-10	0.013	1000	1.2	1.E+02	1.00E+07	2.00E+04	3	
Rh-106m	131 min	β$^-$ / ph	1.90E-10	1.60E-10	0.436	1000	1.7	1.E+01 [1]	3.00E+07	4.00E+04	3	
Rh-107	21.7 min	β$^-$ / ph	2.80E-11	2.40E-11	0.051	1000	1.6	1.E+02 [1]	2.00E+08	3.00E+05	3	→ Pd-107
Pd-100	3.63 d	ec / ph	9.70E-10	9.40E-10	0.050	20	0.1	1.E+00 [2]	5.00E+06	9.00E+03	100	→ Rh-100 [6]
Pd-101	8.47 h	ec, β$^+$ / ph	1.00E-10	9.40E-11	0.081	100	0.2	1.E+02	5.00E+07	8.00E+04	30	→ Rh-101m
Pd-103	16.991 d	ec / ph	3.00E-10	1.90E-10	0.019	3	<0.1	1.E+03 [1]	2.00E+07	3.00E+04	1000	→ Rh-103m
Pd-107	6.5 E6 a	β$^-$	2.90E-10	3.70E-11	<0.001	<1	<0.1	1.E+03	2.00E+07	3.00E+04	1000	
Pd-109	13.7012 h	β$^-$ / ph	5.00E-10	5.50E-10	0.010	1000	2	1.E+02 [2]	1.00E+07	2.00E+04	3	

Radionuclide	Half-life	Type of decay/ radiation	Assessment quantities					Clearance limit		Licensing limit	Guidance values		Unstable daughter nuclide
			e_{inh} Sv/Bq	e_{ing} Sv/Bq	h_{10} (mSv/h)/ GBq at 1 m distance	$h_{0.07}$ (mSv/h)/ GBq at 10 cm distance	$h_{c,0.07}$ (mSv/h)/ (kBq/cm^2)	**LL** Bq/g		**LA** Bq	**CA** Bq/m^3	**CS** Bq/ cm^2	
1	2	3	4	5	6	7	8	9		10	11	12	13
Ag-102	12.9 min	ec, β+ / ph	3.20E-11	4.00E-11	0.546	800	1.4	1.E+01	[1]	2.00E+08	3.00E+05	3	
Ag-103	65.7 min	ec, β+ / ph	4.50E-11	4.30E-11	0.125	500	0.8	1.E+01	[1]	1.00E+08	2.00E+05	10	→ Pd-103
Ag-104	69.2 min	ec, β+ / ph	7.10E-11	6.00E-11	0.410	300	0.5	1.E+01	[1]	7.00E+07	1.00E+05	10	
Ag-104m	33.5 min	ec, β+, it / ph	4.50E-11	5.40E-11	0.188	400	0.8	1.E+01	[1]	1.00E+08	2.00E+05	10	→ Ag-104 [6]
Ag-105	41.29 d	ec / ph	8.00E-10	4.70E-10	0.102	50	0.1	1.E+00		6.00E+06	1.00E+04	100	
Ag-106	23.96 min	ec, β+, b- / ph	2.70E-11	3.20E-11	0.117	700	1	1.E+01	[1]	2.00E+08	3.00E+05	10	
Ag-106m	8.28 d	ec / ph	1.60E-09	1.50E-09	0.435	60	0.2	1.E+00		3.00E+06	5.00E+03	30	
Ag-108m / Ag-108	418 a	ec, it / ph	1.90E-08	2.30E-09	0.263	100	0.3	1.E-01	[2]	3.00E+05	4.00E+02	30	
Ag-110m / Ag-110	249.76 d	β−, it / ph	7.30E-09	2.80E-09	0.409	500	0.6	1.E-01	[2]	7.00E+05	1.00E+03	10	
Ag-111	7.45 d	β− / ph	1.60E-09	1.30E-09	0.004	1000	1.6	1.E+02		3.00E+06	5.00E+03	3	
Ag-112	3.130 h	β− / ph	2.60E-10	4.30E-10	0.640	1000	1.7	1.E+01	[1]	2.00E+07	3.00E+04	3	
Ag-115	20.0 min	β− / ph	4.40E-11	6.00E-11	0.181	1000	1.7	1.E+01	[1]	1.00E+08	2.00E+05	3	→ Cd-115, Cd-115m
Cd-104	57.7 min	ec / ph	6.30E-11	5.80E-11	0.062	20	0.1	1.E+02	[1]	8.00E+07	1.00E+05	100	→ Ag-104 [6]
Cd-107	6.50 h	ec, β+ / ph	1.10E-10	6.20E-11	0.030	20	0.6	1.E+03	[1]	5.00E+07	8.00E+04	10	
Cd-109	461.4 d	ec / ph	9.60E-09	2.00E-09	0.027	5	0.4	1.E+00	[2]	5.00E+05	9.00E+02	10	
Cd-113	7.7 E15 a	β−	1.40E-07	2.50E-08	<0.001	1000	0.9	1.E-01		4.00E+04	6.00E+01	10	
Cd-113m	14.1 a	β−, it	1.30E-07	2.30E-08	<0.001	1000	1.4	1.E-01	[2]	4.00E+04	6.00E+01	3	
Cd-115	53.46 h	β− / ph	1.30E-09	1.40E-09	0.037	1000	1.5	1.E+01	[2]	4.00E+06	6.00E+03	3	→ In-115
Cd-115m	44.6 d	β− / ph	6.40E-09	3.30E-09	0.003	1000	1.6	1.E+02	[2]	8.00E+05	1.00E+03	3	→ In-115
Cd-117	2.49 h	β− / ph	2.50E-10	2.80E-10	0.158	1000	1.5	1.E+01	[1]	2.00E+07	3.00E+04	3	→ In-117m, In-117
Cd-117m	3.36 h	β− / ph	3.20E-10	2.80E-10	0.282	1000	1.5	1.E+01	[1]	2.00E+07	3.00E+04	3	→ In-117, In-117m
In-109	4.2 h	ec, β+ / ph	7.30E-11	6.60E-11	0.117	300	0.3	1.E+01	[1]	7.00E+07	1.00E+05	30	→ Cd-109
In-110	4.9 h	ec, β+ / ph	2.50E-10	2.40E-10	0.468	60	0.2	1.E+01	[1]	2.00E+07	3.00E+04	30	
In-110m	69.1 min	ec, β+ / ph	8.10E-11	1.00E-10	0.238	700	1.1	1.E+01	[1]	6.00E+07	1.00E+05	3	
In-111	2.8047 d	ec / ph	3.10E-10	2.90E-10	0.082	400	0.3	1.E+01	[2]	2.00E+07	3.00E+04	30	

Radionuclide	Half-life	Type of decay/ radiation	Assessment quantities					Clearance limit		Licensing limit	Guidance values		Unstable daughter nuclide
			e_{inh} Sv/Bq	e_{ing} Sv/Bq	h_{10} (mSv/h)/ GBq at 1 m distance	$h_{0,07}$ (mSv/h)/ GBq at 10 cm distance	$h_{c,0,07}$ (mSv/h)/ (kBq/cm²)	**LL** Bq/g		**LA** Bq	**CA** Bq/m³	**CS** Bq/ cm²	
1	2	3	4	5	6	7	8	9		10	11	12	13
In-112	14.97 min	ec, β+, β− / ph	1.30E-11	1.00E-11	0.047	900	1	1.E+02	[1]	4.00E+08	6.00E+05	10	
In-113m	1.6579 h	it / ph	3.20E-11	2.80E-11	0.047	500	0.6	1.E+02	[1]	2.00E+08	3.00E+05	10	
In-114m / In-114	49.51 d	it, ec / ph	1.10E-08	4.10E-09	0.023	3000	3.2	1.E+01	[2]	5.00E+05	8.00E+02	3	
In-115	4.41 E14 a	β−	4.50E-07	3.20E-08	<0.001	1000	1.3	1.E+02		1.00E+04	2.00E+01	3	
In-115m	4.486 h	it, β− / ph	8.70E-11	8.60E-11	0.033	900	1	1.E+02		6.00E+07	1.00E+05	10	→ In-115
In-116m	54.41 min	β− / ph	8.00E-11	6.40E-11	0.356	1000	1.7	1.E+01	[1]	6.00E+07	1.00E+05	3	
In-117	43.2 min	β− / ph	4.80E-11	3.10E-11	0.109	2000	1.8	1.E+01	[1]	1.00E+08	2.00E+05	3	
In-117m	116.2 min	β−, it / ph	1.10E-10	1.20E-10	0.019	1000	1.4	1.E+02	[1]	5.00E+07	8.00E+04	3	→ In-117 [6]
In-119m / In-119	18.0 min	β−, it / ph	2.90E-11	4.70E-11	0.033	1000	1.7	1.E+02	[1]	2.00E+08	3.00E+05	3	
Sn-110	4.11 h	ec / ph	2.60E-10	3.50E-10	0.064	70	0.1	1.E+02	[2]	2.00E+07	3.00E+04	100	→ In-110S [6]
Sn-111	35.3 min	ec, β+ / ph	2.20E-11	2.30E-11	0.087	400	0.6	1.E+02	[1]	2.00E+08	4.00E+05	10	→ In-111
Sn-113	115.09 d	ec / ph	1.90E-09	7.30E-10	0.019	4	<0.1	1.E+00	[2]	3.00E+06	4.00E+03	300	→ In-113m
Sn-117m	13.76 d	it / ph	2.20E-09	7.10E-10	0.038	3000	2.4	1.E+02		2.00E+06	4.00E+03	3	
Sn-119m	293.1 d	it / ph	1.50E-09	3.40E-10	0.011	1	<0.1	1.E+01		3.00E+06	6.00E+03	1000	
Sn-121	27.03 h	β−	2.80E-10	2.30E-10	<0.001	1000	1.1	1.E+03		2.00E+07	3.00E+04	3	
Sn-121m	43.9 a	it, β− / ph	3.30E-09	3.80E-10	0.004	300	0.3	1.E+00	[2]	2.00E+06	3.00E+03	30	→ Sn-121
Sn-123	129.2 d	β− / ph	5.60E-09	2.10E-09	0.001	1000	1.6	1.E+02		9.00E+05	1.00E+03	3	
Sn-123m	40.06 min	β− / ph	4.40E-11	3.80E-11	0.024	2000	1.9	1.E+02	[1]	1.00E+08	2.00E+05	3	
Sn-125	9.64 d	β− / ph	2.80E-09	3.10E-09	0.053	1000	1.5	1.E+01		2.00E+06	3.00E+03	3	→ Sb-125
Sn-126	2.30 E5 a	β− / ph	1.80E-08	4.70E-09	0.017	1000	1.2	1.E-01	[2]	3.00E+05	5.00E+02	3	→ Sb-126 [6]
Sn-127	2.10 h	β− / ph	2.00E-10	2.00E-10	0.313	1000	1.6	1.E+01	[1]	3.00E+07	4.00E+04	3	→ Sb-127 [6]
Sn-128	59.07 min	β− / ph	1.50E-10	1.50E-10	0.138	1000	1.5	1.E+01	[1]	3.00E+07	6.00E+04	3	→ Sb-128S [6]
Sb-115	32.1 min	ec, β+ / ph	2.30E-11	2.40E-11	0.151	400	0.6	1.E+01	[1]	2.00E+08	4.00E+05	10	
Sb-116	15.8 min	ec, β+ / ph	2.30E-11	2.60E-11	0.321	500	0.9	1.E+01	[1]	2.00E+08	4.00E+05	10	
Sb-116m	60.3 min	ec, β+ / ph	8.50E-11	6.70E-11	0.487	400	0.9	1.E+01	[1]	6.00E+07	1.00E+05	10	
Sb-117	2.80 h	ec, β+ / ph	2.70E-11	1.80E-11	0.045	400	0.3	1.E+02	[1]	2.00E+08	3.00E+05	30	
Sb-118m	5.00 h	ec, β+ / ph	2.30E-10	2.10E-10	0.411	200	0.3	1.E+01	[1]	2.00E+07	4.00E+04	30	
Sb-119	38.19 h	ec / ph	5.90E-11	8.10E-11	0.022	3	<0.1	1.E+03	[1]	8.00E+07	1.00E+05	1000	

Radionuclide	Half-life	Type of decay/ radiation	Assessment quantities					Clearance limit		Licensing limit	Guidance values		Unstable daughter nuclide
			e_{inh} Sv/Bq	e_{ing} Sv/Bq	h_{10} (mSv/h)/ GBq at 1 m distance	$h_{0.07}$ (mSv/h)/ GBq at 10 cm distance	$h_{c,0.07}$ (mSv/h)/ (kBq/cm^2)	**LL** Bq/g		**LA** Bq	**CA** Bq/m^3	**CS** Bq/ cm^2	
1	2	3	4	5	6	7	8	9		10	11	12	13
Sb-120	15.89 min	ec, β$^+$ / ph	1.20E-11	1.40E-11	0.079	500	0.7	1.E+02	[1]	4.00E+08	7.00E+05	10	
Sb-120m	5.76 d	ec / ph	1.30E-09	1.20E-09	0.386	400	0.4	1.E+00		4.00E+06	6.00E+03	10	
Sb-122	2.7238 d	β$^-$, ec, β$^+$ / ph	1.20E-09	1.70E-09	0.068	1000	1.6	1.E+01		4.00E+06	7.00E+03	3	
Sb-124	60.20 d	β$^-$ / ph	4.70E-09	2.50E-09	0.261	1000	1.5	1.E+00		1.00E+06	2.00E+03	3	
Sb-124n	20.2 min	it / ph	8.30E-12	8.00E-12	<0.001	<1	<0.1	1.E+02	[1]	6.00E+08	1.00E+06	1000	→ Sb-124 [6]
Sb-125	2.75856 a	β$^-$ / ph	3.30E-09	1.10E-09	0.076	700	0.7	1.E-01	[2]	2.00E+06	3.00E+03	10	→ Te-125m
Sb-126	12.35 d	β$^-$ / ph	3.20E-09	2.40E-09	0.434	1000	1.5	1.E+00		2.00E+06	3.00E+03	3	
Sb-126m	19.15 min	β$^-$, it / ph	3.30E-11	3.60E-11	0.239	1000	1.5	1.E+01	[1]	2.00E+08	3.00E+05	3	→ Sb-126 [6]
Sb-127	3.85 d	β$^-$ / ph	1.70E-09	1.70E-09	0.106	1000	1.6	1.E+01	[2]	3.00E+06	5.00E+03	3	→ Te-127, Te-127m
Sb-128	9.01 h	β$^-$ / ph	6.70E-10	7.60E-10	0.472	1000	1.8	1.E+01		7.00E+06	1.00E+04	3	
Sb-128m	10.4 min	β$^-$, it / ph	2.60E-11	3.30E-11	0.313	1000	1.8	1.E+01	[1]	2.00E+08	3.00E+05	3	
Sb-129	4.40 h	β$^-$ / ph	3.50E-10	4.20E-10	0.212	1000	1.6	1.E+01	[1]	1.00E+07	2.00E+04	3	→ Te-129, Te-129m
Sb-130	39.5 min	β$^-$ / ph	9.10E-11	9.10E-11	0.505	2000	2.1	1.E+01	[1]	5.00E+07	9.00E+04	3	
Sb-131	23.03 min	β$^-$ / ph	8.30E-11	1.00E-10	0.278	1000	1.7	1.E+01	[1]	6.00E+07	1.00E+05	3	→ Te-131, Te-131m
Te-116	2.49 h	ec, β$^+$ / ph	1.70E-10	1.70E-10	0.033	8	0.2	1.E+02	[1]	3.00E+07	5.00E+04	30	→ Sb-116 [6]
Te-119m	4.70 d	ec, β$^+$ / ph						1.E+00		8.00E+06	1.00E+04	300	
Te-121	19.16 d	ec / ph	4.40E-10	4.30E-10	0.104	20	0.1	1.E+01		1.00E+07	2.00E+04	100	
Te-121m	154 d	it, ec / ph	3.60E-09	2.30E-09	0.043	200	0.4	1.E+00		1.00E+06	2.00E+03	10	→ Te-121 [6]
Te-123	6.00 E14 a	ec / ph	5.00E-09	4.40E-09	0.017	2	<0.1	1.E-01		1.00E+06	2.00E+03	100	
Te-123m	119.25 d	it / ph	3.40E-09	1.40E-09	0.032	400	0.8	1.E+00		1.00E+06	2.00E+03	10	→ Te-123
Te-125m	57.40 d	it / ph	2.90E-09	8.70E-10	0.027	500	1.1	1.E+03		2.00E+06	3.00E+03	3	
Te-127	9.35 h	β$^-$ / ph	1.80E-10	1.70E-10	0.001	1000	1.4	1.E+03		3.00E+07	5.00E+04	3	
Te-127m	109 d	it, β$^-$ / ph	6.20E-09	2.30E-09	0.009	40	0.5	1.E+01	[2]	8.00E+05	1.00E+03	10	→ Te-127
Te-129	69.6 min	β$^-$ / ph	5.70E-11	6.30E-11	0.012	1000	1.6	1.E+02	[1]	9.00E+07	1.00E+05	3	→ I-129
Te-129m	33.6 d	it, β$^-$ / ph	5.40E-09	3.00E-09	0.011	600	1.2	1.E+01	[2]	9.00E+05	2.00E+03	3	→ Te-129

Radionuclide	Half-life	Type of decay/ radiation	Assessment quantities					Clearance limit		Licensing limit	Guidance values		Unstable daughter nuclide
			e_{inh} Sv/Bq	e_{ing} Sv/Bq	h_{10} (mSv/h)/ GBq at 1 m distance	$h_{0,07}$ (mSv/h)/ GBq at 10 cm distance	$h_{c,0,07}$ (mSv/h)/ (kBq/cm^2)	**LL** Bq/g		**LA** Bq	**CA** Bq/m^3	**CS** Bq/ cm^2	
1	2	3	4	5	6	7	8	9		10	11	12	13
Te-131	25.0 min	β$^-$ / ph	6.10E-11	8.70E-11	0.067	2000	2	1.E+02		8.00E+07	1.00E+05	3	→ I-131
Te-131m	30 h	β$^-$, it / ph	1.60E-09	1.90E-09	0.208	2000	1.5	1.E+01	[2]	3.00E+06	5.00E+03	3	→ I-131, Te-131
Te-132	3.204 d	β$^-$ / ph	3.00E-09	3.70E-09	0.050	700	0.7	1.E+00	[2]	2.00E+06	3.00E+03	10	→ I-132 [6]
Te-133	12.5 min	β$^-$ / ph	4.40E-11	7.20E-11	0.151	1000	1.7	1.E+01	[1]	1.00E+08	2.00E+05	3	→ I-133
Te-133m	55.4 min	β$^-$, it / ph	1.90E-10	2.80E-10	0.344	1000	1.8	1.E+01	[1]	3.00E+07	4.00E+04	3	→ I-133, Te-133
Te-134	41.8 min	β$^-$ / ph	1.10E-10	1.10E-10	0.142	2000	1.7	1.E+01	[1]	5.00E+07	8.00E+04	3	→ I-134 [6]
I-120	81.6 min	ec, β$^+$ / ph	1.90E-10	3.40E-10	1.155	800	1.5	1.E+01	[1]	3.00E+07	4.00E+04	3	
I-120m	53 min	ec, β$^+$ / ph	1.40E-10	2.10E-10	1.108	800	1.7	1.E+01	[1]	4.00E+07	6.00E+04	3	
I-121	2.12 h	ec, β$^+$ / ph	3.90E-11	8.20E-11	0.077	400	0.4	1.E+02	[1]	1.00E+08	2.00E+05	10	→ Te-121
I-123	13.27 h	ec / ph	1.10E-10	2.10E-10	0.043	400	0.3	1.E+02		5.00E+07	8.00E+04	30	→ Te-123
I-124	4.1760 d	ec, β$^+$ / ph	6.30E-09	1.30E-08	0.170	300	0.5	1.E+01		8.00E+05	1.00E+03	10	
I-125	59.400 d	ec / ph	7.30E-09	1.50E-08	0.033	4	<0.1	1.E+02		7.00E+05	1.00E+03	10	
I-126	12.93 d	ec, β$^+$, β$^-$ / ph	1.40E-08	2.90E-08	0.078	700	0.7	1.E+01		4.00E+05	6.00E+02	10	
I-128	24.99 min	β$^-$, ec, β$^+$ / ph	2.20E-11	4.60E-11	0.016	1000	1.5	1.E+02	[1]	2.00E+08	4.00E+05	3	
I-129	1.57 E7 a	β$^-$ / ph	5.10E-08	1.10E-07	0.016	100	0.3	1.E-02		1.00E+05	2.00E+02	3	→ Xe-129
I-130	12.36 h	β$^-$ / ph	9.60E-10	2.00E-09	0.325	1000	1.6	1.E+01		5.00E+06	9.00E+03	3	
I-131	8.02070 d	β$^-$ / ph	1.10E-08	2.20E-08	0.062	1000	1.4	1.E+01		5.00E+05	8.00E+02	3	→ Xe-131m
I-132	2.295 h	β$^-$ / ph	2.00E-10	2.90E-10	0.338	1000	1.7	1.E+01	[1]	3.00E+07	4.00E+04	3	
I-132m	1.387 h	it, β$^-$ / ph	1.10E-10	2.20E-10	0.055	300	1	1.E+02		5.00E+07	8.00E+04	10	→ I-132 [6]
I-133	20.8 h	β$^-$ / ph	2.10E-09	4.30E-09	0.093	1000	1.6	1.E+01		2.00E+06	4.00E+03	3	→ Xe-133, Xe-133m
I-134	52.5 min	β$^-$ / ph	7.90E-11	1.10E-10	0.385	1000	1.8	1.E+01	[1]	6.00E+07	1.00E+05	3	
I-135	6.57 h	β$^-$ / ph	4.60E-10	9.30E-10	0.223	1000	1.6	1.E+01	[2]	1.00E+07	2.00E+04	3	→ Xe-135, Xe-135m
Xe-122 / I-122	20.1 h	ec, β$^+$ / ph			0.284	800	1.3			7.00E+07	7.00E+04		
Xe-123	2.08 h	ec, β$^+$ / ph			0.107	800	0.9			1.00E+08	1.00E+05		→ I-123

Radionuclide	Half-life	Type of decay/ radiation	Assessment quantities					Clearance limit		Licensing limit	Guidance values		Unstable daughter nuclide
			e_{inh} Sv/Bq	e_{ing} Sv/Bq	h_{10} (mSv/h)/ GBq at 1 m distance	$h_{0.07}$ (mSv/h)/ GBq at 10 cm distance	$h_{c,0.07}$ (mSv/h)/ (kBq/cm^2)	**LL** Bq/g		**LA** Bq	**CA** Bq/m^3	**CS** Bq/ cm^2	
1	2	3	4	5	6	7	8	9		10	11	12	13
Xe-125	16.9 h	ec, β^+ / ph			0.060	300	0.2			3.00E+08	3.00E+05		→ I-125
Xe-127	36.4 d	ec / ph			0.059	400	0.3			2.00E+08	2.00E+05		
Xe-129m	8.88 d	it / ph			0.030	3000	1.9			3.00E+09	3.00E+06		
Xe-131m	11.84 d	it / ph			0.012	3000	2.1			8.00E+09	8.00E+06		
Xe-133	5.243 d	β^- / ph			0.016	1000	1			2.00E+09	2.00E+06		
Xe-133m	2.19 d	it / ph			0.016	2000	1.7			2.00E+09	2.00E+06		→ Xe-133
Xe-135	9.14 h	β^- / ph			0.040	2000	1.6			3.00E+08	3.00E+05		→ Cs-135
Xe-135m	15.29 min	it, β^- / ph			0.069	200	0.4			2.00E+08	2.00E+05		→ Cs-135
Xe-137	3.818 min	β^- / ph			1.167	2	1.7			3.00E+08	3.00E+05		
Xe-138	14.08 min	β^- / ph			0.166	1000	1.7			5.00E+07	5.00E+04		→ Cs-138 [6]
Cs-125	45 min	ec, β^+ / ph	2.30E-11	3.50E-11	0.114	500	0.7	1.E+01	[1]	2.00E+08	4.00E+05	10	→ Xe-125
Cs-127	6.25 h	ec, β^+ / ph	4.00E-11	2.40E-11	0.079	100	0.2	1.E+02		1.00E+08	2.00E+05	30	→ Xe-127
Cs-129	32.06 h	ec, β^+ / ph	8.10E-11	6.00E-11	0.063	30	<0.1	1.E+01		6.00E+07	1.00E+05	1000	
Cs-130	29.21 min	ec, β^+, β^- / ph	1.50E-11	2.80E-11	0.087	500	0.8	1.E+02	[1]	3.00E+08	6.00E+05	10	
Cs-131	9.689 d	ec / ph	4.50E-11	5.80E-11	0.016	2	<0.1	1.E+03	[1]	1.00E+08	2.00E+05	1000	
Cs-132	6.479 d	ec, β^+, β^- / ph	3.80E-10	5.00E-10	0.119	50	0.1	1.E+01		1.00E+07	2.00E+04	100	
Cs-134	2.0648 a	β^-, ec / ph	9.60E-09	1.90E-08	0.236	1000	1.1	1.E-01		5.00E+05	9.00E+02	3	
Cs-134m	2.903 h	it / ph	2.60E-11	2.00E-11	0.009	1000	1.5	1.E+03		2.00E+08	3.00E+05	3	→ Cs-134 [6]
Cs-135	2.3 E6 a	β^-	9.90E-10	2.00E-09	0.000	600	0.7	1.E+02		5.00E+06	8.00E+03	10	
Cs-135m	53 min	it / ph	2.40E-11	1.90E-11	0.239	70	0.2	1.E+01	[1]	2.00E+08	3.00E+05	30	→ Cs-135
Cs-136	13.16 d	β^- / ph	1.90E-09	3.00E-09	0.327	1000	1.5	1.E+00		3.00E+06	4.00E+03	3	
Cs-137 / Ba-137m	30.1671 a	β^-, it / ph	6.70E-09	1.30E-08	0.092	2000	1.5	1.E-01	[2]	7.00E+05	1.00E+03	3	
Cs-138	33.41 min	β^- / ph	4.60E-11	9.20E-11	0.445	1000	1.8	1.E+01	[1]	1.00E+08	2.00E+05	3	
Ba-126 / Cs-126	100 min	ec, β^+ / ph	1.20E-10	2.60E-10	0.805	900	1.6	1.E+02	[1]	4.00E+07	7.00E+04	3	
Ba-128 / Cs-128	2.43 d	ec, β^+ / ph	1.30E-09	2.70E-09	0.209	700	1.2	1.E+02	[2]	4.00E+06	6.00E+03	3	
Ba-131	11.50 d	ec / ph	3.50E-10	4.50E-10	0.087	300	0.4	1.E+01		1.00E+07	2.00E+04	10	→ Cs-131
Ba-131m	14.6 min	it / ph	6.40E-12	4.90E-12	0.019	50	0.4	1.E+02	[1]	8.00E+08	1.00E+06	10	→ Ba-131
Ba-133	10.52 a	ec / ph	1.80E-09	1.00E-09	0.085	70	0.1	1.E-01		3.00E+06	5.00E+03	100	

Radionuclide	Half-life	Type of decay/ radiation	Assessment quantities					Clearance limit		Licensing limit	Guidance values		Unstable daughter nuclide
			e_{inh} Sv/Bq	e_{ing} Sv/Bq	h_{10} (mSv/h)/ GBq at 1 m distance	$h_{0,07}$ (mSv/h)/ GBq at 10 cm distance	$h_{c,0,07}$ (mSv/h)/ (kBq/cm^2)	**LL** Bq/g		**LA** Bq	**CA** Bq/m^3	**CS** Bq/ cm^2	
1	2	3	4	5	6	7	8	9		10	11	12	13
Ba-133m	38.9 h	it, ec / ph	2.80E-10	5.50E-10	0.019	2000	1.5	1.E+02		2.00E+07	3.00E+04	3	→ Ba-133
Ba-135m	28.7 h	it / ph	2.30E-10	4.50E-10	0.018	2000	1.5	1.E+02		2.00E+07	4.00E+04	3	
Ba-139	83.06 min	β$^-$ / ph	5.50E-11	1.20E-10	0.012	1000	1.7	1.E+02	[1]	9.00E+07	2.00E+05	3	
Ba-140	12.752 d	β$^-$ / ph	1.60E-09	2.50E-09	0.031	1000	1.5	1.E+00		3.00E+06	5.00E+03	3	→ La-140 [6]
Ba-141	18.27 min	β$^-$ / ph	3.50E-11	7.00E-11	0.152	1000	1.9	1.E+02	[1]	1.00E+08	2.00E+05	3	→ La-141
Ba-142	10.6 min	β$^-$ / ph	2.70E-11	3.50E-11	0.160	1000	1.7	1.E+02	[1]	2.00E+08	3.00E+05	3	→ La-142 [6]
La-131	59 min	ec, β$^+$ / ph	3.60E-11	3.50E-11	0.116	400	0.6	1.E+01	[1]	1.00E+08	2.00E+05	10	→ Ba-131
La-132	4.8 h	ec, β$^+$ / ph	2.80E-10	3.90E-10	0.379	400	0.8	1.E+01	[1]	2.00E+07	3.00E+04	10	
La-135	19.5 h	ec, β$^+$ / ph	2.50E-11	3.00E-11	0.017	2	<0.1	1.E+03		2.00E+08	3.00E+05	1000	
La-137	6.0 E4 a	ec / ph	1.00E-08	8.10E-11	0.014	2	<0.1	1.E+02		5.00E+05	8.00E+02	1000	
La-138	1.02 E11 a	ec, β$^-$ / ph	1.80E-07	1.10E-09	0.185	400	0.4	1.E-01		3.00E+04	5.00E+01	10	
La-140	1.6781 d	β$^-$ / ph	1.50E-09	2.00E-09	0.332	1000	1.8	1.E+00		3.00E+06	6.00E+03	3	
La-141	3.92 h	β$^-$ / ph	2.20E-10	3.60E-10	0.016	1000	1.6	1.E+02	[1]	2.00E+07	4.00E+04	3	→ Ce-141
La-142	91.1 min	β$^-$ / ph	1.50E-10	1.80E-10	0.490	1000	1.8	1.E+01	[1]	3.00E+07	6.00E+04	3	
La-143	14.2 min	β$^-$ / ph	3.30E-11	5.60E-11	0.219	1000	1.6	1.E+02	[1]	2.00E+08	3.00E+05	3	→ Ce-143
Ce-134 / La -134	3.16 d	ec, β$^+$ / ph	1.60E-09	2.50E-09	0.149	600	1	1.E+03	[2]	3.00E+06	5.00E+03	10	
Ce-135	17.7 h	ec, β$^+$ / ph	7.60E-10	7.90E-10	0.271	2000	1.8	1.E+01		7.00E+06	1.00E+04	3	→ La-135
Ce-137	9.0 h	ec, β$^+$ / ph	1.90E-11	2.50E-11	0.016	10	<0.1	1.E+03		3.00E+08	4.00E+05	1000	→ La-137
Ce-137m	34.4 h	it, ec / ph	5.90E-10	5.40E-10	0.016	2000	1.6	1.E+02	[2]	8.00E+06	1.00E+04	3	→ Ce-137, La-137
Ce-139	137.641 d	ec / ph	1.40E-09	2.60E-10	0.036	500	0.5	1.E+00		4.00E+06	6.00E+03	10	
Ce-141	32.508 d	β$^-$ / ph	3.10E-09	7.10E-10	0.014	2000	1.6	1.E+02		2.00E+06	3.00E+03	3	
Ce-143	33.039 h	β$^-$ / ph	1.00E-09	1.10E-09	0.053	1000	1.6	1.E+01		5.00E+06	8.00E+03	3	→ Pr-143
Ce-144 / Pr-144m	284.91 d	β$^-$ / ph	2.90E-08	5.20E-09	0.005	800	0.9	1.E+01	[2]	2.00E+05	3.00E+02	10	→ Pr-144
Pr-136	13.1 min	ec, β$^+$ / ph	2.50E-11	3.30E-11	0.375	600	1.1	1.E+01	[1]	2.00E+08	3.00E+05	3	
Pr-137	1.28 h	ec, β$^+$ / ph	3.50E-11	4.00E-11	0.083	300	0.5	1.E+02	[1]	1.00E+08	2.00E+05	10	→ Ce-137
Pr-138m	2.12 h	ec, β$^+$ / ph	1.30E-10	1.30E-10	0.379	600	0.8	1.E+01	[1]	4.00E+07	6.00E+04	10	
Pr-139	4.41 h	ec, β$^+$ / ph	3.00E-11	3.10E-11	0.028	100	0.1	1.E+02	[1]	2.00E+08	3.00E+05	100	→ Ce-139

Radionuclide	Half-life	Type of decay/ radiation	Assessment quantities					Clearance limit		Licensing limit	Guidance values		Unstable daughter nuclide
			e_{inh} Sv/Bq	e_{ing} Sv/Bq	h_{10} (mSv/h)/ GBq at 1 m distance	$h_{0.07}$ (mSv/h)/ GBq at 10 cm distance	$h_{c,0.07}$ (mSv/h)/ (kBq/cm^2)	**LL** Bq/g		**LA** Bq	**CA** Bq/m^3	**CS** Bq/ cm^2	
1	2	3	4	5	6	7	8	9		10	11	12	13
Pr-142	19.12 h	β−, ec / ph	7.40E-10	1.30E-09	0.011	1000	1.6	1.E+02		7.00E+06	1.00E+04	3	
Pr-142m	14.6 min	it / ph	9.40E-12	1.70E-11	<0.001	<1	<0.1	1.E+07	[1]	5.00E+08	9.00E+05	1000	→ Pr-142
Pr-143	13.57 d	β−	2.20E-09	1.20E-09	0.000	1000	1.5	1.E+03		2.00E+06	4.00E+03	3	
Pr-144	17.28 min	β− / ph	3.00E-11	5.00E-11	0.099	1000	1.6	1.E+02	[1]	2.00E+08	3.00E+05	3	
Pr-145	5.984 h	β− / ph	2.60E-10	3.90E-10	0.002	1000	1.6	1.E+03		2.00E+07	3.00E+04	3	
Pr-147	13.4 min	β− / ph	3.00E-11	3.30E-11	0.144	1000	1.8	1.E+01	[1]	2.00E+08	3.00E+05	3	→ Nd-147
Nd-136	50.65 min	ec, β+ / ph	8.90E-11	9.90E-11	0.061	200	0.3	1.E+02	[1]	6.00E+07	9.00E+04	30	→ Pr-136 [6]
Nd-138 / Pr-138	5.04 h	ec / ph	3.80E-10	6.40E-10	0.398	700	1.3	1.E+03	[2]	1.00E+07	2.00E+04	3	
Nd-139	29.7 min	ec, β+ / ph	1.70E-11	2.00E-11	0.070	300	0.4	1.E+02	[1]	3.00E+08	5.00E+05	10	→ Pr-139
Nd-139m	5.50 h	ec, β+, it / ph	2.50E-10	2.50E-10	0.246	500	0.6	1.E+01	[1]	2.00E+07	3.00E+04	10	→ Pr-139, Nd-139
Nd-140	3.37 d	ec / ph						1.E+04	[2]	3.00E+06	4.00E+03	100	
Nd-141	2.49 h	ec, β+ / ph	8.80E-12	8.30E-12	0.021	50	0.1	1.E+02	[1]	6.00E+08	9.00E+05	100	
Nd-147	10.98 d	β− / ph	2.10E-09	1.10E-09	0.027	1000	1.5	1.E+02		2.00E+06	4.00E+03	3	→ Pm-147
Nd-149	1.728 h	β− / ph	1.30E-10	1.20E-10	0.063	2000	1.8	1.E+02	[1]	4.00E+07	6.00E+04	3	→ Pm-149
Nd-151	12.44 min	β− / ph	2.90E-11	3.00E-11	0.137	1000	1.7	1.E+01	[1]	2.00E+08	3.00E+05	3	→ Pm-151
Pm-141	20.90 min	ec, β+ / ph	2.50E-11	3.60E-11	0.137	500	0.9	1.E+01	[1]	2.00E+08	3.00E+05	10	→ Nd-141, Nd-141m
Pm-143	265 d	ec / ph	9.60E-10	2.30E-10	0.057	7	<0.1	1.E+00		5.00E+06	9.00E+03	1000	
Pm-144	363 d	ec / ph	5.40E-09	9.70E-10	0.248	40	0.1	1.E-01		9.00E+05	2.00E+03	100	
Pm-145	17.7 a	ec, α / ph	2.40E-09	1.10E-10	0.013	10	<0.1	1.E+01		2.00E+06	3.00E+03	1000	
Pm-146	5.53 a	ec, β− / ph	1.30E-08	9.00E-10	0.122	500	0.6	1.E-01		4.00E+05	6.00E+02	10	→ Sm-146
Pm-147	2.6234 a	β−	3.50E-09	2.60E-10	<0.001	500	0.6	1.E+03		1.00E+06	2.00E+03	10	→ Sm-147
Pm-148	5.368 d	β− / ph	2.20E-09	2.70E-09	0.091	1000	1.6	1.E+01		2.00E+06	4.00E+03	3	
Pm-148m	41.29 d	β−, it / ph	4.30E-09	1.80E-09	0.306	1000	1.4	1.E+00		1.00E+06	2.00E+03	3	→ Sm-148
Pm-149	53.08 h	β− / ph	8.20E-10	9.90E-10	0.002	1000	1.6	1.E+03		6.00E+06	1.00E+04	3	
Pm-150	2.68 h	β− / ph	2.10E-10	2.60E-10	0.226	1000	1.8	1.E+01	[1]	2.00E+07	4.00E+04	3	
Pm-151	28.40 h	β− / ph	6.40E-10	7.30E-10	0.052	1000	1.5	1.E+01		8.00E+06	1.00E+04	3	→ Sm-151

Radionuclide	Half-life	Type of decay/ radiation	Assessment quantities					Clearance limit		Licensing limit	Guidance values		Unstable daughter nuclide
			e_{inh} Sv/Bq	e_{ing} Sv/Bq	h_{10} (mSv/h)/ GBq at 1 m distance	$h_{0,07}$ (mSv/h)/ GBq at 10 cm distance	$h_{c,0,07}$ (mSv/h)/ (kBq/cm²)	**LL** Bq/g		**LA** Bq	**CA** Bq/m³	**CS** Bq/ cm²	
1	2	3	4	5	6	7	8	9		10	11	12	13
Sm-141	10.2 min	ec, β^+ / ph	2.70E-11	3.90E-11	0.287	500	1	1.E+01	[1]	2.00E+08	3.00E+05	10	→ Pm-141 [6]
Sm-141m	22.6 min	ec, β^+, it / ph	5.60E-11	6.50E-11	0.338	900	1.1	1.E+01	[1]	9.00E+07	1.00E+05	3	→ Pm-141, Sm-141
Sm-142 / Pm-142	72.49 min	ec, β^+ / ph	1.10E-10	1.90E-10	0.752	800	1.5	1.E+02	[1]	5.00E+07	8.00E+04	3	
Sm-145	340 d	ec / ph	1.10E-09	2.10E-10	0.026	20	<0.1	1.E+02		5.00E+06	8.00E+03	1000	→ Pm-145
Sm-146	1.03 E8 a	α	6.70E-06	5.40E-08	<0.001	<1	<0.1	1.E+00		7.00E+02	1.00E+00	3	
Sm-147	1.060 E11 a	α	6.10E-06	4.90E-08	<0.001	<1	<0.1	1.E+00		8.00E+02	1.00E+00	3	
Sm-151	90 a	β^-	2.60E-09	9.80E-11	<0.001	<1	<0.1	1.E+03		2.00E+06	3.00E+03	1000	
Sm-153	46.50 h	β^- / ph	6.80E-10	7.40E-10	0.016	1000	1.6	1.E+02		7.00E+06	1.00E+04	3	
Sm-155	22.3 min	β^- / ph	2.80E-11	2.90E-11	0.019	1000	1.6	1.E+02	[1]	2.00E+08	3.00E+05	3	→ Eu-155
Sm-156	9.4 h	β^- / ph	2.80E-10	2.50E-10	0.022	1000	1.4	1.E+02		2.00E+07	3.00E+04	3	→ Eu-156 [6]
Eu-145	5.93 d	ec, β^+ / ph	7.30E-10	7.50E-10	0.217	60	0.2	1.E+00		7.00E+06	1.00E+04	30	→ Sm-145
Eu-146	4.61 d	ec, β^+ / ph	1.20E-09	1.30E-09	0.375	100	0.3	1.E+00		4.00E+06	7.00E+03	30	→ Sm-146
Eu-147	24.1 d	ec, β^+, α / ph	1.00E-09	4.40E-10	0.085	300	0.3	1.E+01		5.00E+06	8.00E+03	30	→ Sm-147, Pm-143
Eu-148	54.5 d	ec, β^+, α / ph	2.30E-09	1.30E-09	0.327	70	0.2	1.E+00		2.00E+06	4.00E+03	30	→ Pm-144
Eu-149	93.1 d	ec / ph	2.30E-10	1.00E-10	0.018	20	<0.1	1.E+01		2.00E+07	4.00E+04	1000	
Eu-150	36.9 a	ec, β^+ / ph	3.40E-08	1.30E-09	0.238	100	0.2	1.E-01		1.00E+05	2.00E+02	30	
Eu-150m	12.8 h	β^-, ec, β^+ / ph	2.80E-10	3.80E-10	0.008	1000	1.4	1.E+03	[1]	2.00E+07	3.00E+04	3	
Eu-152	13.537 a	ec, β^+, β^- / ph	2.70E-08	1.40E-09	0.179	700	0.8	1.E-01		2.00E+05	3.00E+02	10	→ Gd-152
Eu-152m	9.3116 h	β^-, ec, β^+ / ph	3.20E-10	5.00E-10	0.047	900	1.3	1.E+02		2.00E+07	3.00E+04	3	→ Gd-152
Eu-154	8.593 a	β^-, ec / ph	3.50E-08	2.00E-09	0.185	2000	1.8	1.E-01		1.00E+05	2.00E+02	3	
Eu-155	4.7611 a	β^- / ph	4.70E-09	3.20E-10	0.012	200	0.3	1.E+00		1.00E+06	2.00E+03	30	
Eu-156	15.19 d	β^- / ph	3.00E-09	2.20E-09	0.188	1000	1.5	1.E+00		2.00E+06	3.00E+03	3	
Eu-157	15.18 h	β^- / ph	4.40E-10	6.00E-10	0.049	1000	1.6	1.E+02		1.00E+07	2.00E+04	3	
Eu-158	45.9 min	β^- / ph	7.50E-11	9.40E-11	0.220	1000	1.8	1.E+01	[1]	7.00E+07	1.00E+05	3	
Gd-145	23.0 min	ec, β^+ / ph	3.50E-11	4.40E-11	0.360	500	0.9	1.E+01	[1]	1.00E+08	2.00E+05	10	→ Eu-145 [6]
Gd-146	48.27 d	ec / ph	5.20E-09	9.60E-10	0.057	600	0.9	1.E+00	[2]	1.00E+06	2.00E+03	10	→ Eu-146 [6]

Radionuclide	Half-life	Type of decay/ radiation	Assessment quantities					Clearance limit		Licensing limit	Guidance values		Unstable daughter nuclide
			e_{inh} Sv/Bq	e_{ing} Sv/Bq	h_{10} (mSv/h)/ GBq at 1 m distance	$h_{0.07}$ (mSv/h)/ GBq at 10 cm distance	$h_{c,0.07}$ (mSv/h)/ (kBq/cm^2)	**LL** Bq/g		**LA** Bq	**CA** Bq/m^3	**CS** Bq/ cm^2	
1	2	3	4	5	6	7	8	9		10	11	12	13
Gd-147	38.1 h	ec, β^+ / ph	5.90E-10	6.10E-10	0.206	400	0.4	1.E+01	[1]	8.00E+06	1.00E+04	10	→ Eu-147
Gd-148	74.6 a	α	3.00E-05	5.50E-08	<0.001	<1	<0.1	1.E+00		2.00E+02	3.00E-01	3	
Gd-149	9.28 d	ec, β^+ / ph	7.90E-10	4.50E-10	0.076	400	0.6	1.E+01		6.00E+06	1.00E+04	10	→ Eu-149
Gd-151	124 d	ec, αα / ph	9.30E-10	2.00E-10	0.018	200	0.2	1.E+01		5.00E+06	9.00E+03	30	→ Sm-147
Gd-152	1.08 E14 a	α	2.20E-05	4.10E-08	<0.001	<1	<0.1	1.E+01	[1]	2.00E+02	4.00E-01	3	
Gd-153	240.4 d	ec / ph	2.50E-09	2.70E-10	0.029	30	0.1	1.E+01		2.00E+06	3.00E+03	100	
Gd-159	18.479 h	β^- / ph	3.90E-10	4.90E-10	0.010	1000	1.5	1.E+02		1.00E+07	2.00E+04	3	
Tb-147	1.64 h	ec, β^+ / ph	1.20E-10	1.60E-10	0.356	400	0.8	1.E+01	[1]	4.00E+07	7.00E+04	10	→ Gd-147 [6]
Tb-149	4.118 h	ec, β^+, α / ph	3.10E-09	2.50E-10	0.241	400	0.6	1.E-01		2.00E+06	3.00E+03	10	→ Gd-149, Eu-145
Tb-150	3.48 h	ec, β^+, α / ph	1.80E-10	2.50E-10	0.346	400	0.8	1.E+01	[1]	3.00E+07	5.00E+04	10	
Tb-151	17.609 h	ec, β^+, α / ph	3.30E-10	3.40E-10	0.147	400	0.6	1.E+01		2.00E+07	3.00E+04	10	→ Gd-151, Eu-147
Tb-153	2.34 d	ec, β^+ / ph	2.40E-10	2.50E-10	0.045	100	0.1	1.E+01		2.00E+07	3.00E+04	100	→ Gd-153
Tb-154	21.5 h	ec, β^+ / ph	6.00E-10	6.50E-10	0.313	400	0.6	1.E+01	[1]	8.00E+06	1.00E+04	10	
Tb-155	5.32 d	ec / ph	2.50E-10	2.10E-10	0.031	200	0.2	1.E+02		2.00E+07	3.00E+04	30	
Tb-156	5.35 d	ec / ph	1.40E-09	1.20E-09	0.277	500	0.8	1.E+00		4.00E+06	6.00E+03	10	
Tb-156m	24.4 h	it / ph	2.30E-10	1.70E-10	0.007	4	<0.1	1.E+01		2.00E+07	4.00E+04	1000	
Tb-156n	5.3 h	it / ph	1.30E-10	8.10E-11	0.001	8	0.6	1.E+04	[1]	4.00E+07	6.00E+04	10	→ Tb-156 [6]
Tb-157	71 a	ec / ph	7.90E-10	3.40E-11	0.001	6	<0.1	1.E+02		6.00E+06	1.00E+04	1000	
Tb-158	180 a	ec, β^- / ph	3.00E-08	1.10E-09	0.127	400	0.6	1.E-01		2.00E+05	3.00E+02	10	
Tb-160	72.3 d	β^- / ph	5.40E-09	1.60E-09	0.169	1000	1.7	1.E+00		9.00E+05	2.00E+03	3	
Tb-161	6.906 d	β^- / ph	1.20E-09	7.20E-10	0.013	1000	1.3	1.E+03		4.00E+06	7.00E+03	3	
Dy-155	9.9 h	ec, β^+ / ph	1.20E-10	1.30E-10	0.094	100	0.1	1.E+01	[1]	4.00E+07	7.00E+04	100	→ Tb-155
Dy-157	8.14 h	ec / ph	5.50E-11	6.10E-11	0.065	40	0.1	1.E+02		9.00E+07	2.00E+05	100	→ Tb-157
Dy-159	144.4 d	ec / ph	2.50E-10	1.00E-10	0.015	10	<0.1	1.E+03		2.00E+07	3.00E+04	1000	
Dy-165	2.334 h	β^- / ph	8.70E-11	1.10E-10	0.005	1000	1.6	1.E+03		6.00E+07	1.00E+05	3	
Dy-166	81.6 h	β^- / ph	1.80E-09	1.60E-09	0.010	1000	1.1	1.E+02		3.00E+06	5.00E+03	3	→ Ho-166

Radionuclide	Half-life	Type of decay/ radiation	Assessment quantities					Clearance limit		Licensing limit	Guidance values		Unstable daughter nuclide
			e_{inh} Sv/Bq	e_{ing} Sv/Bq	h_{10} (mSv/h)/ GBq at 1 m distance	$h_{0,07}$ (mSv/h)/ GBq at 10 cm distance	$h_{c,0,07}$ (mSv/h)/ (kBq/cm^2)	**LL** Bq/g		**LA** Bq	**CA** Bq/m^3	**CS** Bq/ cm^2	
1	2	3	4	5	6	7	8	9		10	11	12	13
Ho-155	48 min	ec, β^+ / ph	3.20E-11	3.70E-11	0.066	300	0.5	1.E+02	[1]	2.00E+08	3.00E+05	10	→ Dy-155
Ho-157	12.6 min	ec, β^+ / ph	7.60E-12	6.50E-12	0.088	300	0.3	1.E+02	[1]	7.00E+08	1.00E+06	30	→ Dy-157
Ho-159	33.05 min	ec, β^+ / ph	1.00E-11	7.90E-12	0.069	200	0.2	1.E+02	[1]	5.00E+08	8.00E+05	30	→ Dy-159
Ho-161	2.48 h	ec / ph	1.00E-11	1.30E-11	0.022	20	<0.1	1.E+02	[1]	5.00E+08	8.00E+05	1000	
Ho-162	15.0 min	ec, β^+ / ph	4.50E-12	3.30E-12	0.032	70	0.2	1.E+02	[1]	1.00E+09	2.00E+06	30	
Ho-162m	67.0 min	it, ec, β^+ / ph	3.30E-11	2.60E-11	0.094	300	0.3	1.E+01	[1]	2.00E+08	3.00E+05	30	→ Ho-162
Ho-164	29 min	ec, β^- / ph	1.30E-11	9.50E-12	0.009	600	0.7	1.E+03	[1]	4.00E+08	6.00E+05	10	
Ho-164m	38.0 min	it / ph	1.60E-11	1.60E-11	0.014	20	<0.1	1.E+03	[1]	3.00E+08	5.00E+05	1000	→ Ho-164
Ho-166	26.80 h	β^- / ph	8.30E-10	1.40E-09	0.005	1000	1.7	1.E+02		6.00E+06	1.00E+04	3	
Ho-166m	1.20 E3 a	β^- / ph	7.80E-08	2.00E-09	0.268	800	0.9	1.E-01		6.00E+04	1.00E+02	10	
Ho-167	3.1 h	β^- / ph	1.00E-10	8.30E-11	0.061	1000	1.4	1.E+02	[1]	5.00E+07	8.00E+04	3	
Er-161	3.21 h	ec, β^+	8.50E-11	8.00E-11	0.139	400	0.4	1.E+01	[1]	6.00E+07	1.00E+05	10	→ Ho-161
Er-165	10.36 h	ec	1.40E-11	1.90E-11	0.011	7	<0.1	1.E+03	[1]	4.00E+08	6.00E+05	1000	
Er-169	9.40 d	β^-	9.20E-10	3.70E-10	<0.001	1000	1	1.E+03		5.00E+06	9.00E+03	10	
Er-171	7.516 h	β^-	3.00E-10	3.60E-10	0.064	2000	1.9	1.E+02		2.00E+07	3.00E+04	3	→ Tm-171
Er-172	49.3 h	β^-	1.20E-09	1.00E-09	0.084	1000	1	1.E+01		4.00E+06	7.00E+03	10	→ Tm-172
Tm-162	21.70 min	ec, β^+ / ph	2.70E-11	2.90E-11	0.261	300	0.9	1.E+01	[1]	2.00E+08	3.00E+05	10	
Tm-166	7.70 h	ec, β^+ / ph	2.80E-10	2.80E-10	0.270	200	0.4	1.E+01		2.00E+07	3.00E+04	10	
Tm-167	9.25 d	ec / ph	1.00E-09	5.60E-10	0.029	2000	1.1	1.E+02	[1]	5.00E+06	8.00E+03	3	
Tm-170	128.6 d	β^-, ec / ph	5.20E-09	1.30E-09	0.001	1000	1.6	1.E+02		1.00E+06	2.00E+03	3	
Tm-171	1.92 a	β^- / ph	9.10E-10	1.10E-10	<0.001	<1	<0.1	1.E+03		5.00E+06	9.00E+03	1000	
Tm-172	63.6 h	β^- / ph	1.40E-09	1.70E-09	0.069	1000	1.5	1.E+01		4.00E+06	6.00E+03	3	
Tm-173	8.24 h	β^- / ph	2.60E-10	3.10E-10	0.063	1000	1.6	1.E+02		2.00E+07	3.00E+04	3	
Tm-175	15.2 min	β^- / ph	3.10E-11	2.70E-11	0.160	2000	2	1.E+01	[1]	2.00E+08	3.00E+05	3	→ Yb-175
Yb-162	18.87 min	ec, β^+ / ph	2.30E-11	2.30E-11	0.027	60	0.1	1.E+02	[1]	2.00E+08	4.00E+05	100	→ Tm-162 [6]
Yb-166	56.7 h	ec / ph	9.50E-10	9.50E-10	0.022	10	0.1	1.E+02	[1]	5.00E+06	9.00E+03	100	→ Tm-166 [6]
Yb-167	17.5 min	ec, β^+ / ph	9.50E-12	6.70E-12	0.053	200	0.4	1.E+02	[1]	5.00E+08	9.00E+05	10	→ Tm-167
Yb-169	32.026 d	ec / ph	2.40E-09	7.10E-10	0.061	1000	1	1.E+01		2.00E+06	3.00E+03	10	

Radionuclide	Half-life	Type of decay/ radiation	Assessment quantities					Clearance limit		Licensing limit	Guidance values		Unstable daughter nuclide
			e_{inh} Sv/Bq	e_{ing} Sv/Bq	h_{10} (mSv/h)/ GBq at 1 m distance	$h_{0.07}$ (mSv/h)/ GBq at 10 cm distance	$h_{c,0.07}$ (mSv/h)/ (kBq/cm^2)	**LL** Bq/g		**LA** Bq	**CA** Bq/m^3	**CS** Bq/ cm^2	
1	2	3	4	5	6	7	8	9		10	11	12	13
Yb-175	4.185 d	β$^-$ / ph	7.00E-10	4.40E-10	0.007	1000	1.1	1.E+02		7.00E+06	1.00E+04	3	
Yb-177	1.911 h	β$^-$ / ph	9.40E-11	9.70E-11	0.028	1000	1.5	1.E+02	[1]	5.00E+07	9.00E+04	3	→ Lu-177
Yb-178	74 min	β$^-$ / ph	1.10E-10	1.20E-10	0.006	1000	1.3	1.E+03	[2]	5.00E+07	8.00E+04	3	→ Lu-178
Lu-169	34.06 h	ec, β$^+$ / ph	4.90E-10	4.60E-10	0.154	100	0.2	1.E+01	[1]	1.00E+07	2.00E+04	30	→ Yb-169
Lu-170	2.012 d	ec, β$^+$ / ph	9.50E-10	9.90E-10	0.281	60	0.3	1.E+01	[1]	5.00E+06	9.00E+03	30	
Lu-171	8.24 d	ec, β$^+$ / ph	9.30E-10	6.70E-10	0.115	30	0.1	1.E+01		5.00E+06	9.00E+03	100	
Lu-172	6.70 d	ec, β$^+$ / ph	1.80E-09	1.30E-09	0.283	300	0.5	1.E+00		3.00E+06	5.00E+03	10	
Lu-173	1.37 a	ec / ph	1.50E-09	2.60E-10	0.028	30	0.1	1.E+00		3.00E+06	6.00E+03	100	
Lu-174	3.31 a	ec, β$^+$ / ph	2.90E-09	2.70E-10	0.024	10	<0.1	1.E+00		2.00E+06	3.00E+03	1000	
Lu-174m	142 d	it, ec / ph	2.60E-09	5.30E-10	0.015	30	<0.1	1.E+01		2.00E+06	3.00E+03	300	→ Lu-174
Lu-176	3.85 E10 a	β$^-$ / ph	4.60E-08	1.80E-09	0.081	2000	2.3	1.E-01		1.00E+05	2.00E+02	3	
Lu-176m	3.635 h	β$^-$, ec / ph	1.60E-10	1.70E-10	0.003	1000	1.8	1.E+03		3.00E+07	5.00E+04	3	
Lu-177	6.647 d	β$^-$ / ph	1.10E-09	5.30E-10	0.006	1000	1.3	1.E+02		5.00E+06	8.00E+03	3	
Lu-177m	160.4 d	β$^-$, it / ph	1.20E-08	1.70E-09	0.166	2000	2.6	1.E-01	[2]	4.00E+05	7.00E+02	3	→ Lu-177
Lu-178	28.4 min	β$^-$ / ph	4.10E-11	4.70E-11	0.022	1000	1.8	1.E+02	[1]	1.00E+08	2.00E+05	3	
Lu-178m	23.1 min	β$^-$ / ph	5.60E-11	3.80E-11	0.182	2000	2.8	1.E+01	[1]	9.00E+07	1.00E+05	3	
Lu-179	4.59 h	β$^-$ / ph	1.60E-10	2.10E-10	0.005	1000	1.6	1.E+03		3.00E+07	5.00E+04	3	
Hf-170	16.01 h	ec / ph	4.30E-10	4.80E-10	0.091	200	0.3	1.E+02	[1]	1.00E+07	2.00E+04	30	→ Lu-170 [6]
Hf-172	1.87 a	ec / ph	3.70E-08	1.00E-09	0.030	100	0.1	1.E+01	[2]	1.00E+05	2.00E+02	100	→ Lu-172 [6]
Hf-173	23.6 h	ec, β$^+$ / ph	2.20E-10	2.30E-10	0.071	300	0.3	1.E+01		2.00E+07	4.00E+04	30	→ Lu-173
Hf-175	70 d	ec / ph	8.80E-10	4.10E-10	0.065	200	0.2	1.E+00		6.00E+06	9.00E+03	30	
Hf-177m	51.4 min	it / ph	1.50E-10	8.10E-11	0.370	4000	4.5	1.E+01	[1]	3.00E+07	6.00E+04	1	
Hf-178m	31 a	it / ph	3.10E-07	4.70E-09	0.378	2000	2.1	1.E+01	[1]	2.00E+04	3.00E+01	3	
Hf-179m	25.05 d	it / ph	3.20E-09	1.20E-09	0.149	1000	1.6	1.E+01	[1]	2.00E+06	3.00E+03	3	
Hf-180m	5.5 h	it, β$^-$ / ph	2.00E-10	1.70E-10	0.166	700	1.1	1.E+01	[1]	3.00E+07	4.00E+04	3	
Hf-181	42.39 d	β$^-$ / ph	4.10E-09	1.10E-09	0.089	2000	1.9	1.E+00		1.00E+06	2.00E+03	3	
Hf-182	9E6 a	β$^-$ / ph	3.60E-07	3.00E-09	0.039	500	0.6	1.E-01	[2]	1.00E+04	2.00E+01	10	→ Ta-182 [6]

Radionuclide	Half-life	Type of decay/ radiation	Assessment quantities					Clearance limit		Licensing limit	Guidance values		Unstable daughter nuclide
			e_{inh} Sv/Bq	e_{ing} Sv/Bq	h_{10} (mSv/h)/ GBq at 1 m distance	$h_{0,07}$ (mSv/h)/ GBq at 10 cm distance	$h_{c,0,07}$ (mSv/h)/ (kBq/cm²)	**LL** Bq/g		**LA** Bq	**CA** Bq/m³	**CS** Bq/ cm²	
1	2	3	4	5	6	7	8	9		10	11	12	13
Hf-182m	61.5 min	β⁻, it / ph	7.10E-11	4.20E-11	0.150	1000	1.8	1.E+01	[1]	7.00E+07	1.00E+05	3	→ Ta-182 [6], Hf-182
Hf-183	1.067 h	β⁻ / ph	8.30E-11	7.30E-11	0.116	1000	1.6	1.E+01	[1]	6.00E+07	1.00E+05	3	→ Ta-183
Hf-184	4.12 h	β⁻ / ph	4.50E-10	5.20E-10	0.043	2000	2.2	1.E+02	[1]	1.00E+07	2.00E+04	3	→ Ta-184
Ta-172	36.8 min	ec, β⁺ / ph	5.70E-11	5.30E-11	0.244	700	1.5	1.E+01	[1]	9.00E+07	1.00E+05	3	→ Hf-172 [6]
Ta-173	3.14 h	ec, β⁺ / ph	1.60E-10	1.90E-10	0.098	500	0.7	1.E+01	[1]	3.00E+07	5.00E+04	10	→ Hf-173
Ta-174	1.14 h	ec, β⁺ / ph	6.60E-11	5.70E-11	0.106	700	1.2	1.E+01	[1]	8.00E+07	1.00E+05	3	→ Hf-174
Ta-175	10.5 h	ec, β⁺ / ph	2.00E-10	2.10E-10	0.137	200	0.3	1.E+01	[1]	3.00E+07	4.00E+04	30	→ Hf-175
Ta-176	8.09 h	ec, β⁺ / ph	3.30E-10	3.10E-10	0.280	100	0.5	1.E+01		2.00E+07	3.00E+04	10	
Ta-177	56.56 h	ec / ph	1.30E-10	1.10E-10	0.015	100	0.2	1.E+02	[1]	4.00E+07	6.00E+04	30	
Ta-178	9.31 min	ec, β⁺ / ph			0.021	10	0.2	1.E+01	[1]			30	
Ta-178m	2.36 h	ec / ph	1.10E-10	7.80E-11	0.172	700	1.2			5.00E+07	8.00E+04	3	
Ta-179	1.82 a	ec / ph	2.90E-10	6.50E-11	0.008	6	<0.1	1.E+01		2.00E+07	3.00E+04	1000	
Ta-180	8.152 h	ec, β⁻ / ph	6.20E-11	5.40E-11	0.011	200	0.4	1.E+01	[1]	8.00E+07	1.00E+05	10	
Ta-180m	1E13 a		1.40E-08	8.40E-10	0.094	600	1	1.E+03		4.00E+05	6.00E+02	10	
Ta-182	114.43 d	β⁻ / ph	7.40E-09	1.50E-09	0.194	1000	1.8	1.E-01		7.00E+05	1.00E+03	3	
Ta-182m	15.84 min	it / ph	3.60E-11	1.20E-11	0.044	3000	2.7	1.E+02	[1]	1.00E+08	2.00E+05	3	→ Ta-182 [6]
Ta-183	5.1 d	β⁻ / ph	2.00E-09	1.30E-09	0.051	2000	2.3	1.E+01		3.00E+06	4.00E+03	3	
Ta-184	8.7 h	β⁻ / ph	6.30E-10	6.80E-10	0.247	2000	2.8	1.E+01	[1]	8.00E+06	1.00E+04	3	
Ta-185	49.4 min	β⁻ / ph	7.20E-11	6.80E-11	0.033	2000	2.3	1.E+02	[1]	7.00E+07	1.00E+05	3	→ W-185
Ta-186	10.5 min	β⁻ / ph	3.10E-11	3.30E-11	0.252	2000	2.5	1.E+01	[1]	2.00E+08	3.00E+05	3	
W-176	2.3 h		7.60E-11	1.10E-10	0.036	20	0.1	1.E+02	[1]	7.00E+07	1.00E+05	100	→ Ta-176 [6]
W-177	132 min	ec, β⁺ / ph	4.60E-11	6.10E-11	0.140	300	0.4	1.E+01	[1]	1.00E+08	2.00E+05	10	→ Ta-177
W-178 / Ta-178-1	21.6 d	ec / ph	1.20E-10	2.50E-10	0.024	20	0.2	1.E+01	[1]	4.00E+07	7.00E+04	30	
W-179	37.05 min	ec / ph	1.80E-12	3.30E-12	0.019	10	<0.1	1.E+02	[1]	3.00E+09	5.00E+06	1000	→ Ta-179
W-181	121.2 d	ec / ph	4.30E-11	8.20E-11	0.009	7	<0.1	1.E+01		1.00E+08	2.00E+05	1000	
W-185	75.1 d	β⁻	2.20E-10	5.00E-10	<0.001	1000	1.1	1.E+03		2.00E+07	4.00E+04	3	

Radionuclide	Half-life	Type of decay/ radiation	Assessment quantities					Clearance limit		Licensing limit	Guidance values		Unstable daughter nuclide
			e_{inh} Sv/Bq	e_{ing} Sv/Bq	h_{10} (mSv/h)/ GBq at 1 m distance	$h_{0.07}$ (mSv/h)/ GBq at 10 cm distance	$h_{c,0.07}$ (mSv/h)/ (kBq/cm^2)	**LL** Bq/g		**LA** Bq	**CA** Bq/m^3	**CS** Bq/ cm^2	
1	2	3	4	5	6	7	8	9		10	11	12	13
W-187	23.72 h	β$^-$ / ph	3.30E-10	7.10E-10	0.075	2000	1.6	1.E+01		2.00E+07	3.00E+04	3	→ Re-187
W-188	69.78 d	β$^-$ / ph	8.40E-10	2.30E-09	<0.001	1000	1	1.E+01	[2]	6.00E+06	1.00E+04	10	→ Re-188
Re-177	0.233 h		2.20E-11	2.20E-11	0.100	300	0.8	1.E+01	[1]	2.00E+08	4.00E+05	10	→ W-177 [6]
Re-178	13.2 min	ec, β$^+$ / ph	2.40E-11	2.50E-11	0.256	700	1.6	1.E+01	[1]	2.00E+08	3.00E+05	3	→ W-178
Re-181	19.9 h	ec, β$^+$ / ph	3.70E-10	4.20E-10	0.124	500	0.6	1.E+01		1.00E+07	2.00E+04	10	→ W-181
Re-182	64.0 h	ec / ph	1.70E-09	1.40E-09	0.177	80	0.6	1.E+00		3.00E+06	5.00E+03	10	
Re-182m	12.7 h	ec, β$^+$ / ph	3.00E-10	2.70E-10	0.282	900	1.7	1.E+01		2.00E+07	3.00E+04	3	
Re-183	70.0 d	ec / ph						1.E+01		3.00E+06	5.00E+03	300	
Re-184	38.0 d	ec, β$^+$ / ph	1.80E-09	1.00E-09	0.138	300	0.6	1.E+00		3.00E+06	5.00E+03	10	
Re-184m	169 d	it, ec / ph	4.80E-09	1.50E-09	0.063	300	0.8	1.E-01		1.00E+06	2.00E+03	10	→ Re-184 [6]
Re-186	3.7183 d	β$^-$, ec / ph	1.20E-09	1.50E-09	0.004	2000	1.6	1.E+03		4.00E+06	7.00E+03	3	
Re-186m	2.00 E5 a	it / ph	7.90E-09	2.20E-09	0.004	10	0.1	1.E+00	[2]	6.00E+05	1.00E+03	100	→ Re-186
Re-187	4.12 E10 a	β$^-$	4.60E-12	5.10E-12	<0.001	<1	<0.1	1.E+03		1.00E+09	2.00E+06	1000	
Re-188	17.0040 h	β$^-$ / ph	7.40E-10	1.40E-09	0.010	1000	1.8	1.E+02		7.00E+06	1.00E+04	3	
Re-188m	18.59 min	it / ph	2.00E-11	3.00E-11	0.016	40	0.2	1.E+02	[1]	3.00E+08	4.00E+05	30	→ Re-188
Re-189	24.3 h	β$^-$ / ph	6.00E-10	7.80E-10	0.011	2000	1.6	1.E+02	[2]	8.00E+06	1.00E+04	3	→ Os-189m
Os-180 / Re-180	21.5 min	ec, β$^+$ / ph	2.50E-11	1.70E-11	0.199	300	1	1.E+02	[1]	2.00E+08	3.00E+05	10	
Os-181	105 min	ec, β$^+$ / ph	1.00E-10	8.90E-11	0.186	400	0.6	1.E+01	[1]	5.00E+07	8.00E+04	10	→ Re-181 [6]
Os-182	22.10 h	ec / ph	5.20E-10	5.60E-10	0.071	100	0.2	1.E+01		1.00E+07	2.00E+04	30	→ Re-182-1 [6]
Os-185	93.6 d	ec / ph	1.40E-09	5.10E-10	0.112	40	0.1	1.E+00		4.00E+06	6.00E+03	100	
Os-189m	5.8 h	it / ph	7.90E-12	1.80E-11	<0.001	5	<0.1	1.E+04	[1]	6.00E+08	1.00E+06	1000	
Os-191	15.4 d	β$^-$ / ph	1.50E-09	5.70E-10	0.015	400	0.4	1.E+02	[2]	3.00E+06	6.00E+03	10	
Os-191m	13.10 h	it / ph	1.40E-10	9.60E-11	0.002	5	0.1	1.E+03		4.00E+07	6.00E+04	100	→ Os-191
Os-193	30.11 h	β$^-$ / ph	6.80E-10	8.10E-10	0.012	1000	1.6	1.E+02		7.00E+06	1.00E+04	3	
Os-194	6.0 a	β$^-$ / ph	4.20E-08	2.40E-09	0.001	2	<0.1	1.E+00	[2]	1.00E+05	2.00E+02	100	→ Ir-194
Ir-182	15 min	ec, β$^+$ / ph	4.00E-11	4.80E-11	0.584	1000	1.9	1.E+01	[1]	1.00E+08	2.00E+05	3	→ Os-182
Ir-184	3.09 h	ec, β$^+$ / ph	1.90E-10	1.70E-10	0.296	1000	1.5	1.E+01	[1]	3.00E+07	4.00E+04	3	
Ir-185	14.4 h	ec, β$^+$ / ph	2.60E-10	2.60E-10	0.091	300	0.5	1.E+01	[1]	2.00E+07	3.00E+04	10	→ Os-185 [6]

Radionuclide	Half-life	Type of decay/ radiation	Assessment quantities					Clearance limit		Licensing limit	Guidance values		Unstable daughter nuclide
			e_{inh} Sv/Bq	e_{ing} Sv/Bq	h_{10} (mSv/h)/ GBq at 1 m distance	$h_{0,07}$ (mSv/h)/ GBq at 10 cm distance	$h_{c,0,07}$ (mSv/h)/ (kBq/cm^2)	**LL** Bq/g		**LA** Bq	**CA** Bq/m^3	**CS** Bq/ cm^2	
1	2	3	4	5	6	7	8	9		10	11	12	13
Ir-186	16.64 h	ec, β^+ / ph	5.00E-10	4.90E-10	0.243	1000	1	1.E+01	[1]	1.00E+07	2.00E+04	10	
Ir-186m	1.92 h	ec, β^+, it / ph	7.10E-11	6.10E-11	0.152	900	0.9	1.E+01	[1]	7.00E+07	1.00E+05	10	
Ir-187	10.5 h	ec, β^+ / ph	1.20E-10	1.20E-10	0.059	100	0.1	1.E+02		4.00E+07	7.00E+04	100	
Ir-188	41.5 h	ec, β^+ / ph	6.20E-10	6.30E-10	0.223	500	0.5	1.E+01	[1]	8.00E+06	1.00E+04	10	
Ir-189	13.2 d	ec / ph	4.60E-10	2.40E-10	0.016	50	0.1	1.E+02	[2]	1.00E+07	2.00E+04	100	
Ir-190	11.78 d	ec / ph	2.50E-09	1.20E-09	0.228	800	1.3	1.E+00	[2]	2.00E+06	3.00E+03	3	
Ir-190m	1.120 h	it / ph	1.10E-11	8.00E-12	<0.001	5	<0.1	1.E+04	[1]	5.00E+08	8.00E+05	1000	→ Ir-190 [6]
Ir-190n	3.087 h	ec, it / ph	1.40E-10	1.20E-10	0.247	900	0.9	1.E+01	[1]	4.00E+07	6.00E+04	10	→ Ir-190
Ir-192	73.827 d	β^-, ec / ph	4.90E-09	1.40E-09	0.131	2000	1.6	1.E+00		1.00E+06	2.00E+03	3	
Ir-192n	241 a	it / ph	1.90E-08	3.10E-10	0.025	2	<0.1	1.E+02	[1]	3.00E+05	4.00E+02	1000	→ Ir-192 [6]
Ir-193m	10.53 d	it / ph	1.00E-09	2.70E-10				1.E+04		5.00E+06	8.00E+03	1000	
Ir-194	19.28 h	β^- / ph	7.50E-10	1.30E-09	0.017	1000	1.6	1.E+02		7.00E+06	1.00E+04	3	
Ir-194m	171 d	β^- / ph	8.20E-09	2.10E-09	0.367	1000	1.5	1.E+01	[2]	6.00E+05	1.00E+03	3	
Ir-195	2.5 h	β^- / ph	1.00E-10	1.00E-10	0.012	1000	1.7	1.E+02	[1]	5.00E+07	8.00E+04	3	
Ir-195m	3.8 h	β^-, it / ph	2.40E-10	2.10E-10	0.073	2000	2.6	1.E+02	[1]	2.00E+07	3.00E+04	3	→ Ir-195
Pt-186	2.08 h	ec, α / ph	6.60E-11	9.30E-11	0.115	20	0.1	1.E+01	[1]	8.00E+07	1.00E+05	100	→ Ir-186-1 [6], Os-182
Pt-188	10.2 d	ec, α / ph	6.30E-10	7.60E-10	0.035	800	0.8	1.E+01	[1]	8.00E+06	1.00E+04	10	→ Ir-188 [6]
Pt-189	10.87 h	ec, β^+ / ph	7.30E-11	1.20E-10	0.054	200	0.2	1.E+02		7.00E+07	1.00E+05	30	→ Ir-189
Pt-190	6.50 E11 a	α						1.E+00		2.00E+04	4.00E+01	30	
Pt-191	2.802 d	ec / ph	1.90E-10	3.40E-10	0.053	200	0.3	1.E+01	[2]	3.00E+07	4.00E+04	30	
Pt-193	50 a	ec / ph	2.70E-11	3.10E-11	0.001	4	<0.1	1.E+01		2.00E+08	3.00E+05	1000	
Pt-193m	4.33 d	it / ph	2.10E-10	4.50E-10	0.003	2000	1.8	1.E+03	[1]	2.00E+07	4.00E+04	3	→ Pt-193
Pt-195m	4.02 d	it / ph	3.10E-10	6.30E-10	0.016	2000	2.1	1.E+02	[1]	2.00E+07	3.00E+04	3	
Pt-197	19.8915 h	β^- / ph	1.60E-10	4.00E-10	0.005	1000	1.5	1.E+03		3.00E+07	5.00E+04	3	
Pt-197m	95.41 min	it, β^- / ph	4.30E-11	8.40E-11	0.015	2000	1.6	1.E+02	[1]	1.00E+08	2.00E+05	3	→ Pt-197
Pt-199	30.80 min	β^- / ph	2.20E-11	3.90E-11	0.031	1000	1.7	1.E+02	[1]	2.00E+08	4.00E+05	3	→ Au-199
Pt-200	12.5 h	β^- / ph	4.00E-10	1.20E-09	0.011	1000	1.5	1.E+02	[2]	1.00E+07	2.00E+04	3	→ Au-200

Radionuclide	Half-life	Type of decay/ radiation	Assessment quantities					Clearance limit		Licensing limit	Guidance values		Unstable daughter nuclide
			e_{inh} Sv/Bq	e_{ing} Sv/Bq	h_{10} (mSv/h)/ GBq at 1 m distance	$h_{0.07}$ (mSv/h)/ GBq at 10 cm distance	$h_{c,0.07}$ (mSv/h)/ (kBq/cm^2)	**LL** Bq/g		**LA** Bq	**CA** Bq/m^3	**CS** Bq/ cm^2	
1	2	3	4	5	6	7	8	9		10	11	12	13
Au-193	17.65 h	ec / ph	1.60E-10	1.30E-10	0.029	400	0.5	1.E+02		3.00E+07	5.00E+04	10	→ Pt-193
Au-194	38.02 h	ec, β^+ / ph	3.80E-10	4.20E-10	0.157	200	0.2	1.E+01		1.00E+07	2.00E+04	30	
Au-195	186.098 d	ec / ph	1.20E-09	2.50E-10	0.017	40	0.2	1.E+01		4.00E+06	7.00E+03	30	
Au-196	6.183 d	ec, β^- / ph						1.E+01		1.00E+07	2.00E+04	1000	
Au-198	2.69517 d	β^- / ph	1.10E-09	1.00E-09	0.065	1000	1.6	1.E+01		5.00E+06	8.00E+03	3	
Au-198m	2.27 d	it / ph	2.00E-09	1.30E-09	0.094	3000	3.9	1.E+01		3.00E+06	4.00E+03	1	→ Au-198
Au-199	3.139 d	β^- / ph	7.60E-10	4.40E-10	0.015	2000	1.5	1.E+02		7.00E+06	1.00E+04	3	
Au-200	48.4 min	β^- / ph	5.60E-11	6.80E-11	0.044	1000	1.6	1.E+02	[1]	9.00E+07	1.00E+05	3	
Au-200m	18.7 h	β^-, it / ph	1.00E-09	1.10E-09	0.323	2000	2.1	1.E+01	[1]	5.00E+06	8.00E+03	3	→ Au-200
Au-201	26 min	β^- / ph	2.90E-11	2.40E-11	0.008	1000	1.6	1.E+02	[1]	2.00E+08	3.00E+05	3	
Hg-193	3.80 h	ec, β^+ / ph	1.00E-10	8.20E-11	0.037	800	1.1	1.E+02	[1]	5.00E+07	8.00E+04	3	→ Au-193
Hg-193m	11.8 h	ec, β^+, it / ph	3.80E-10	4.00E-10	0.162	1000	0.9	1.E+01	[1]	1.00E+07	2.00E+04	10	→ Hg-193
Hg-194	440 a	ec / ph	1.90E-08	5.10E-08	0.001	4	<0.1	1.E-01	[2]	3.00E+05	4.00E+02	3	→ Au-194 [6]
Hg-195	10.53 h	ec, β^+ / ph	9.20E-11	9.70E-11	0.034	60	0.1	1.E+02		5.00E+07	9.00E+04	100	→ Au-195
Hg-195m	41.6 h	it, ec, β^+ / ph	6.50E-10	5.60E-10	0.037	1000	1.3	1.E+02	[2]	8.00E+06	1.00E+04	3	→ Hg-195, Au-195
Hg-197	64.94 h	ec / ph	2.80E-10	2.30E-10	0.014	20	0.1	1.E+02		2.00E+07	3.00E+04	100	
Hg-197m	23.8 h	it, ec / ph	6.60E-10	4.70E-10	0.017	3000	2.7	1.E+02		8.00E+06	1.00E+04	3	→ Hg-197
Hg-199m	42.66 min	it / ph	5.20E-11	3.10E-11	0.032	2000	2.3	1.E+02	[1]	1.00E+08	2.00E+05	3	
Hg-203	46.612 d	β^- / ph	1.90E-09	1.90E-09	0.039	800	0.9	1.E+01		3.00E+06	4.00E+03	10	
Tl-194	33.0 min	ec, β^+ / ph	8.90E-12	8.10E-12	0.125	90	0.1	1.E+01	[1]	6.00E+08	9.00E+05	100	→ Hg-194
Tl-194m	32.8 min	ec, β^+ / ph	3.60E-11	4.00E-11	0.368	700	1.3	1.E+01	[1]	1.00E+08	2.00E+05	3	→ Hg-194
Tl-195	1.16 h	ec, β^+ / ph	3.00E-11	2.70E-11	0.159	200	0.3	1.E+01	[1]	2.00E+08	3.00E+05	30	→ Hg-195
Tl-197	2.84 h	ec, β^+ / ph	2.70E-11	2.30E-11	0.065	300	0.3	1.E+02	[1]	2.00E+08	3.00E+05	30	→ Hg-197
Tl-198	5.3 h	ec, β^+ / ph	1.20E-10	7.30E-11	0.280	100	0.2	1.E+01	[1]	4.00E+07	7.00E+04	30	
Tl-198m	1.87 h	ec, β^+, it / ph	7.30E-11	5.40E-11	0.188	2000	1.5	1.E+01	[1]	7.00E+07	1.00E+05	3	→ Tl-198 [6]
Tl-199	7.42 h	ec, β^+ / ph	3.70E-11	2.60E-11	0.042	600	0.5	1.E+02		1.00E+08	2.00E+05	10	
Tl-200	26.1 h	ec, β^+ / ph	2.50E-10	2.00E-10	0.198	100	0.2	1.E+01		2.00E+07	3.00E+04	30	

Radionuclide	Half-life	Type of decay/ radiation	Assessment quantities					Clearance limit		Licensing limit	Guidance values		Unstable daughter nuclide
			e_{inh} Sv/Bq	e_{ing} Sv/Bq	h_{10} (mSv/h)/ GBq at 1 m distance	$h_{0,07}$ (mSv/h)/ GBq at 10 cm distance	$h_{c,0,07}$ (mSv/h)/ (kBq/cm^2)	**LL** Bq/g		**LA** Bq	**CA** Bq/m^3	**CS** Bq/ cm^2	
1	2	3	4	5	6	7	8	9		10	11	12	13
Tl-201	72.912 h	ec / ph	7.60E-11	9.50E-11	0.018	100	0.2	1.E+02		7.00E+07	1.00E+05	30	
Tl-202	12.23 d	ec / ph	3.10E-10	4.50E-10	0.077	60	0.1	1.E+01		2.00E+07	3.00E+04	100	
Tl-204	3.78 a	β^-, ec / ph	6.20E-10	1.30E-09	<0.001	1000	1.4	1.E+00		8.00E+06	1.00E+04	3	→ Pb-204
Tl-209	2.161 min	β^- / ph			0.296	1000	1.9					3	→ Pb-209
Pb-195m	15 min	ec, β^+ / ph	3.00E-11	2.90E-11	0.254	600	1.9	1.E+01	[1]	2.00E+08	3.00E+05	3	→ Tl-195 [6]
Pb-198	2.4 h	ec / ph	8.70E-11	1.00E-10	0.073	600	0.6	1.E+02	[1]	6.00E+07	1.00E+05	10	→ Tl-198 [6]
Pb-199	90 min	ec, β^+ / ph	4.80E-11	5.40E-11	0.218	200	0.3	1.E+01	[1]	1.00E+08	2.00E+05	30	→ Tl-199
Pb-200	21.5 h	ec / ph	2.60E-10	4.00E-10	0.037	1000	1	1.E+01		2.00E+07	3.00E+04	10	→ Tl-200 [6]
Pb-201	9.33 h	ec, β^+ / ph	1.20E-10	1.60E-10	0.120	300	0.3	1.E+01		4.00E+07	7.00E+04	30	→ Tl-201
Pb-202	5.25 E4 a	ec, α / ph	1.40E-08	8.70E-09	0.001	4	<0.1	1.E-01	[2]	4.00E+05	6.00E+02	30	→ Tl-202
Pb-202m	3.53 h	it, ec / ph	1.20E-10	1.30E-10	0.310	900	1	1.E+01	[1]	4.00E+07	7.00E+04	10	→ Pb-202, Tl-202
Pb-203	51.873 h	ec / ph	1.60E-10	2.40E-10	0.054	500	0.4	1.E+01		3.00E+07	5.00E+04	10	
Pb-205	1.53 E7 a	ec / ph	4.10E-10	2.80E-10	0.001	4	<0.1	1.E+01		1.00E+07	2.00E+04	1000	
Pb-209	3.253 h	β^-	3.20E-11	5.70E-11	<0.001	1000	1.4	1.E+03		2.00E+08	3.00E+05	3	
Pb-210	22.20 a	β^-, α / ph	1.10E-06	6.80E-07	0.003	3	<0.1	1.E-01	[2]	5.00E+03	8.00E+00	0.3	→ Bi-210
Pb-211 / Bi-211	36.1 min	β^-, α / ph	5.60E-09	1.80E-10	0.016	1000	1.7	1.E+02	[1]	9.00E+05	1.00E+03	3	
Pb-212	10.64 h	β^- / ph	3.30E-08	5.90E-09	0.025	2000	1.8	1.E+01	[2]	2.00E+05	3.00E+02	3	→ Bi-212 [6]
Pb-214	26.8 min	β^- / ph	4.80E-09	1.40E-10	0.041	2000	1.9	1.E+02	[1]	1.00E+06	2.00E+03	3	→ Bi-214 [6]
Bi-200	36.4 min	ec, β^+ / ph	5.60E-11	5.10E-11	0.371	600	0.7	1.E+01	[1]	9.00E+07	1.00E+05	10	→ Pb-200
Bi-201	108 min	ec, β^+ / ph	1.10E-10	1.20E-10	0.205	500	0.8	1.E+01	[1]	5.00E+07	8.00E+04	10	→ Pb-201 [6]
Bi-202	1.72 h	ec, β^+ / ph	1.00E-10	8.90E-11	0.367	500	0.6	1.E+01	[1]	5.00E+07	8.00E+04	10	→ Pb-202
Bi-203	11.76 h	ec, β^+ / ph	4.50E-10	4.80E-10	0.310	200	0.4	1.E+01	[1]	1.00E+07	2.00E+04	10	→ Pb-203
Bi-205	15.31 d	ec, β^+ / ph	1.00E-09	9.00E-10	0.239	100	0.2	1.E+01	[1]	5.00E+06	8.00E+03	30	→ Pb-205
Bi-206	6.243 d	ec, β^+ / ph	2.10E-09	1.90E-09	0.487	600	1	1.E+00		2.00E+06	4.00E+03	10	
Bi-207	32.9 a	ec, β^+ / ph	3.20E-09	1.30E-09	0.233	100	0.3	1.E-01		2.00E+06	3.00E+03	30	
Bi-208	3.68 E5 a	ec / ph						1.E-02		1.00E+06	2.00E+03	300	
Bi-210	5.013 d	β^-, α	6.00E-08	1.30E-09	<0.001	1000	1.6	1.E+03		8.00E+04	1.00E+02	3	→ Po-210

Radionuclide	Half-life	Type of decay/ radiation	Assessment quantities					Clearance limit		Licensing limit	Guidance values		Unstable daughter nuclide
			e_{inh} Sv/Bq	e_{ing} Sv/Bq	h_{10} (mSv/h)/ GBq at 1 m distance	$h_{0.07}$ (mSv/h)/ GBq at 10 cm distance	$h_{c,0.07}$ (mSv/h)/ (kBq/cm^2)	**LL** Bq/g		**LA** Bq	**CA** Bq/m^3	**CS** Bq/ cm^2	
1	2	3	4	5	6	7	8	9		10	11	12	13
Bi-210m	3.04 E6 a	α / ph	2.10E-06	1.50E-08	0.042	500	0.4	1.E-01	[2]	2.00E+03	4.00E+00	10	→ Tl-206
Bi-212 / Po-212, Tl-208	60.55 min	β$^-$, α / ph	3.90E-08	2.60E-10	0.180	1000	1.7	1.E+01	[1]	1.00E+05	2.00E+02	3	
Bi-213 / Po-213, Tl-209	45.59 min	β$^-$, α / ph	4.10E-08	2.00E-10	0.027	1000	1.6	1.E+02	[1]	1.00E+05	2.00E+02	3	
Bi-214	19.9 min	β$^-$, α / ph	2.10E-08	1.10E-10	0.239	1000	1.7	1.E+01	[1]	2.00E+05	4.00E+02	3	→ Po-214→ Pb-210
Po-203	36.7 min	ec, β$^+$, α / ph	6.10E-11	5.20E-11	0.245	1000	1	1.E+01	[1]	8.00E+07	1.00E+05	10	→ Bi-203 [6]
Po-205	1.66 h	ec, β$^+$, α / ph	8.90E-11	5.90E-11	0.233	200	0.3	1.E+01	[1]	6.00E+07	9.00E+04	30	→ Bi-205 [6], Pb-201
Po-206	8.8 d	ec, α / ph						1.E+00		1.00E+04	2.00E+01	3	→ Bi-206 [6]
Po-207	5.80 h	ec, β$^+$, α / ph	1.50E-10	1.40E-10	0.201	200	0.3	1.E+01	[1]	3.00E+07	6.00E+04	30	→ Bi-207 [6]
Po-208	2.898 a	α, ec						1.E+00		2.00E+03	3.00E+00	0.3	→ Bi-208
Po-209	102 a	α, ec / ph						1.E+00		2.00E+03	3.00E+00	0.3	→ Pb-205
Po-210	138.376 d	α	2.20E-06	2.40E-07	<0.001	<1	<0.1	1.E+00		2.00E+03	4.00E+00	1	
At-207	1.80 h	ec, β$^+$, α / ph	1.90E-09	2.30E-10	0.198	500	0.5	1.E+01	[1]	3.00E+06	4.00E+03	10	→ Po-207 [6], Bi-203
At-211	7.214 h	ec, α / ph	1.10E-07	1.10E-08	0.008	3	<0.1	1.E+03	[2]	5.00E+04	8.00E+01	30	→ Po-211, Bi-207 [6]
Rn-220	55.6 s	α / ph			<0.001	<1	<0.1						→ Po-216→ Pb-212
Rn-222	3.8235 d	α / ph			<0.001	<1	<0.1						→ Po-218→ Pb-214
Fr-222	14.2 min	β$^-$ / ph	2.10E-08	7.10E-10	0.001	1000	1.6	1.E+03	[2]	2.00E+05	4.00E+02	3	→ Ra-222 etc.
Fr-223	22.00 min	β$^-$, α / ph	1.30E-09	2.30E-09	0.017	2000	1.8	1.E+02	[1]	4.00E+06	6.00E+03	3	→ Ra-223
Ra-223	11.43 d	α / ph	5.70E-06	1.00E-07	0.024	600	0.5	1.E+01	[2]	9.00E+02	1.00E+00	3	→ Rn-219→ Po-215→ Pb-211

Radionuclide	Half-life	Type of decay/ radiation	Assessment quantities					Clearance limit		Licensing limit	Guidance values		Unstable daughter nuclide
			e_{inh} Sv/Bq	e_{ing} Sv/Bq	h_{10} (mSv/h)/ GBq at 1 m distance	$h_{0,07}$ (mSv/h)/ GBq at 10 cm distance	$h_{c,0,07}$ (mSv/h)/ (kBq/cm^2)	**LL** Bq/g		**LA** Bq	**CA** Bq/m^3	**CS** Bq/ cm^2	
1	2	3	4	5	6	7	8	9		10	11	12	13
Ra-224	3.66 d	α / ph	2.40E-06	6.50E-08	0.002	30	<0.1	1.E+00	[2]	2.00E+03	3.00E+00	3	→ Rn-220 etc.
Ra-225	14.9 d	β$^-$ / ph	4.80E-06	9.50E-08	0.007	1000	0.9	1.E+01		1.00E+03	2.00E+00	3	→ Ac-225
Ra-226	1600 a	α / ph	2.20E-06	2.80E-07	0.001	50	<0.1	1.E-02	[2]	2.00E+03	4.00E+00	1	→ Rn-222
Ra-226 (+ Töchter)					0.283	5000	5.2	1.E-02		2.00E+03	4.00E+00	1	
Ra-227	42.2 min	β$^-$ / ph	2.10E-10	8.40E-11	0.038	2000	1.8	1.E+02	[1]	2.00E+07	4.00E+04	3	→ Ac-227
Ra-228	5.75 a	β$^-$ / ph	1.70E-06	6.70E-07	<0.001	<1	<0.1	1.E-01	[2]	3.00E+03	5.00E+00	0.3	→ Ac-228
Ac-224	2.78 h	ec, α / ph	9.90E-08	7.00E-10	0.038	100	0.2	1.E+02	[1]	5.00E+04	8.00E+01	30	→ Ra-224, Fr-220 etc.
Ac-225	10.0 d	α / ph	6.50E-06	2.40E-08	0.005	20	0.1	1.E+01	[2]	8.00E+02	1.00E+00	10	→ Fr-221 etc.
Ac-226	29.37 h	β$^-$, ec, α / ph	1.00E-06	1.00E-08	0.024	1000	1.3	1.E+02	[2]	5.00E+03	8.00E+00	3	→ Th-226, Ra-226, Fr-222
Ac-227	21.772 a	β$^-$, α / ph	6.30E-04	1.10E-06	<0.001	<1	<0.1	1.E-02	[2]	8.00E+00	1.00E-02	0.1	→ Th-227, Fr-223
Ac-228	6.15 h	β$^-$ / ph	2.90E-08	4.30E-10	0.145	2000	1.8	1.E+01	[1]	2.00E+05	3.00E+02	3	→ Th-228
Th-226	30.57 min	α / ph	7.80E-08	3.60E-10	0.002	100	0.3	1.E+03	[1]	6.00E+04	1.00E+02	30	→ Ra-222 etc.
Th-227	18.68 d	α / ph	7.60E-06	8.90E-09	0.023	200	0.2	1.E+01		7.00E+02	1.00E+00	10	→ Ra-223
Th-228	1.9116 a	α / ph	3.20E-05	7.00E-08	0.002	3	<0.1	1.E-01	[2]	2.00E+02	3.00E-01	3	→ Ra-224
Th-229	7.34 E3 a	α / ph	6.90E-05	4.80E-07	0.027	300	0.5	1.E-01	[2]	7.00E+01	1.00E-01	0.3	→ Ra-225
Th-230	7.538 E4 a	α / ph	2.80E-05	2.10E-07	0.001	3	<0.1	1.E-01		2.00E+02	3.00E-01	1	→ Ra-226
Th-231	25.52 h	β$^-$ / ph	4.00E-10	3.40E-10	0.019	700	0.8	1.E+03		1.00E+07	2.00E+04	10	→ Pa-231
Th-232	1.405 E10 a	α / ph	2.90E-05	2.20E-07	0.001	3	<0.1	1.E-01	[2]	2.00E+02	3.00E-01	1	→ Ra-228
Th-234 / Pa-234m	24.10 d	β$^-$ / ph	5.80E-09	3.40E-09	0.008	1000	1.9	1.E+02	[2]	9.00E+05	1.00E+03	3	→ Pa-234
Th (+ Töchter)					0.355	6000	5.4			2.00E+02 [11]			
Pa-227	38.3 min	α, ec / ph	9.70E-08	4.50E-10	0.007	5	<0.1	1.E+01	[1]	5.00E+04	9.00E+01	300	→ Ac-223
Pa-228	22 h	ec, β$^+$, α / ph	5.10E-08	7.80E-10	0.168	400	0.9	1.E+01		1.00E+05	2.00E+02	10	→ Th-228, Ac-224

Radionuclide	Half-life	Type of decay/ radiation	Assessment quantities					Clearance limit		Licensing limit	Guidance values		Unstable daughter nuclide
			e_{inh} Sv/Bq	e_{ing} Sv/Bq	h_{10} (mSv/h)/ GBq at 1 m distance	$h_{0.07}$ (mSv/h)/ GBq at 10 cm distance	$h_{c,0.07}$ (mSv/h)/ (kBq/cm^2)	**LL** Bq/g		**LA** Bq	**CA** Bq/m^3	**CS** Bq/ cm^2	
1	2	3	4	5	6	7	8	9		10	11	12	13
Pa-230	17.4 d	ec, β−, α / ph	5.70E-07	9.20E-10	0.108	200	0.3	1.E+01		9.00E+03	1.00E+01	30	→ Th-230, U-230, Ac-226
Pa-231	3.276 E4 a	α / ph	8.90E-05	7.10E-07	0.020	40	0.1	1.E-02		6.00E+01	9.00E-02	0.3	→ Ac-227
Pa-232	1.31 d	β−, ec / ph	6.80E-09	7.20E-10	0.151	1000	1.3	1.E+01		7.00E+05	1.00E+03	3	→ U-232
Pa-233	26.967 d	β− / ph	3.20E-09	8.70E-10	0.041	2000	1.4	1.E+01		2.00E+06	3.00E+03	3	→ U-233
Pa-234	6.70 h	β− / ph	5.80E-10	5.10E-10	0.281	2000	2.9	1.E+01		9.00E+06	1.00E+04	3	→ U-234
U-230	20.8 d	α / ph	1.20E-05	5.50E-08	0.003	6	<0.1	1.E+01	[2]	4.00E+02	7.00E-01	3	→ Th-226
U-231	4.2 d	ec, α / ph	4.00E-10	2.80E-10	0.032	10	0.1	1.E+02		1.00E+07	2.00E+04	100	→ Pa-231, Th-227
U-232	68.9 a	α / ph	2.60E-05	3.30E-07	0.002	6	<0.1	1.E-01	[2]	2.00E+02	3.00E-01	1	→ Th-228
U-233	1.592 E5 a	α / ph	6.90E-06	5.00E-08	0.001	2	<0.1	1.E+00		7.00E+02	1.00E+00	3	→ Th-229
U-234	2.455 E5 a	α / ph	6.80E-06	4.90E-08	0.002	3	<0.1	1.E+00		7.00E+02	1.00E+00	3	→ Th-230
U-235	7.04 E8 a	α / ph	6.10E-06	4.60E-08	0.028	100	0.2	1.E+00	[2]	8.00E+02	1.00E+00	3	→ Th-231
U-236	2.342E7 a	α / ph	6.30E-06	4.60E-08	0.002	1	<0.1	1.E+01	[1]	8.00E+02	1.00E+00	3	→ Th-232
U-237	6.75 d	β− / ph	1.70E-09	7.70E-10	0.037	1000	1.6	1.E+02		3.00E+06	5.00E+03	3	→ Np-237
U-238	4.468 E9 a	α, fs / ph	5.70E-06	4.40E-08	0.002	1	<0.1	1.E+00	[2]	9.00E+02	1.00E+00	10	→ Th-234
U-239	23.45 min	β− / ph	3.50E-11	2.80E-11	0.012	1000	1.6	1.E+02	[1]	1.00E+08	2.00E+05	3	→ Np-239
U-240	14.1 h	β− / ph	8.40E-10	1.10E-09	0.009	1000	1	1.E+02	[2]	6.00E+06	1.00E+04	10	→ Np-240
U (+ Töchter)					0.296	6000	7.1			9.00E+02 [11]			
Np-232	14.7 min	ec, β+ / ph	3.50E-11	9.70E-12	0.199	400	0.6	1.E+01	[1]	1.00E+08	2.00E+05	10	→ U-232
Np-233	36.2 min	ec, α / ph	3.00E-12	2.20E-12	0.022	40	<0.1	1.E+02	[1]	2.00E+09	3.00E+06	1000	→ U-233
Np-234	4.4 d	ec, β+ / ph	7.30E-10	8.10E-10	0.219	80	0.2	1.E+01		7.00E+06	1.00E+04	30	→ U-234
Np-235	396.1 d	ec, α / ph	2.70E-10	5.30E-11	0.008	3	<0.1	1.E+03		2.00E+07	3.00E+04	1000	→ U-235, Pa-231
Np-236	1.54 E5 a	ec, β−, α / ph	2.00E-06	1.70E-08	0.046	1000	1.8	1.E+00		3.00E+03	4.00E+00	3	→ U-236, Pu-236

Radionuclide	Half-life	Type of decay/ radiation	Assessment quantities					Clearance limit		Licensing limit	Guidance values		Unstable daughter nuclide
			e_{inh} Sv/Bq	e_{ing} Sv/Bq	h_{10} (mSv/h)/ GBq at 1 m distance	$h_{0,07}$ (mSv/h)/ GBq at 10 cm distance	$h_{c,0,07}$ (mSv/h)/ (kBq/cm^2)	**LL** Bq/g		**LA** Bq	**CA** Bq/m^3	**CS** Bq/ cm^2	
1	2	3	4	5	6	7	8	9		10	11	12	13
Np-236m	22.5 h	ec, β$^-$ / ph	3.60E-09	1.90E-10	0.013	600	0.6	1.E+02		1.00E+06	2.00E+03	10	→ U-236, Pu-236
Np-237	2.144 E6 a	α / ph	1.50E-05	1.10E-07	0.018	30	0.1	1.E+00	[2]	3.00E+02	6.00E-01	3	→ Pa-233
Np-238	2.117 d	β$^-$ / ph	1.70E-09	9.10E-10	0.089	1000	1.1	1.E+01		3.00E+06	5.00E+03	3	→ Pu-238
Np-239	2.3565 d	β$^-$ / ph	1.10E-09	8.00E-10	0.039	2000	2.3	1.E+02		5.00E+06	8.00E+03	3	→ Pu-239
Np-240	61.9 min	β$^-$ / ph	1.30E-10	8.20E-11	0.225	3000	3.4	1.E+01	[1]	4.00E+07	6.00E+04	1	→ Pu-240
Np-240m	7.22 min	β$^-$, it / ph			0.060	1000	1.6	1.E+03				3	→ Pu-240
Pu-234	8.8 h	ec, α / ph	1.80E-08	1.60E-10	0.018	6	<0.1	1.E+02	[1]	3.00E+05	5.00E+02	1000	→ Np-234, U-230
Pu-235	25.3 min	ec, α / ph	2.60E-12	2.10E-12	0.026	8	<0.1	1.E+02	[1]	2.00E+09	3.00E+06	1000	→ Np-235, U-231
Pu-236	2.858 a	α, fs / ph	1.30E-05	8.60E-08	0.003	1	<0.1	1.E+00		4.00E+02	6.00E-01	3	→ U-232
Pu-237	45.2 d	ec, α / ph	3.00E-10	1.00E-10	0.018	6	<0.1	1.E+02		2.00E+07	3.00E+04	1000	→ Np-237, U-233
Pu-238	87.7 a	α, fs / ph	3.00E-05	2.30E-07	0.002	<1	<0.1	1.E-01		2.00E+02	3.00E-01	1	→ U-234
Pu-239	2.411 E4 a	α / ph	3.20E-05	2.50E-07	0.001	<1	<0.1	1.E-01	[2]	2.00E+02	3.00E-01	1	→ U-235
Pu-240	6564 a	α, fs / ph	3.20E-05	2.50E-07	0.002	<1	<0.1	1.E-01		2.00E+02	3.00E-01	1	→ U-236
Pu-241	14.35 a	β$^-$, a	5.80E-07	4.70E-09	<0.001	<1	<0.1	1.E+01		9.00E+03	1.00E+01	30	→ Am-241, U-237
Pu-242	3.75 E5 a	α, fs / ph	3.10E-05	2.40E-07	0.002	<1	<0.1	1.E-01		2.00E+02	3.00E-01	1	→ U-238
Pu-243	4.956 h	β$^-$ / ph	1.10E-10	8.50E-11	0.007	1000	1.3	1.E+03		5.00E+07	8.00E+04	3	→ Am-243
Pu-244 [9]	8.00 E7 a	α, fs / ph	3.00E-05	2.40E-07	0.053	1	0.1	1.E-01	[2]	2.00E+02	3.00E-01	1	→ U-240
Pu-245	10.5 h	β$^-$ / ph	6.50E-10	7.20E-10	0.070	2000	2	1.E+02	[2]	8.00E+06	1.00E+04	3	→ Am-245
Pu-246	10.84 d	β$^-$ / ph	7.00E-09	3.30E-09	0.034	700	0.7	1.E+01	[2]	7.00E+05	1.00E+03	10	→ Am-246
Am-237	73.0 min	ec, α / ph	3.60E-11	1.80E-11	0.073	800	0.7	1.E+02	[1]	1.00E+08	2.00E+05	10	→ Pu-237, Np-233

Radionuclide	Half-life	Type of decay/ radiation	Assessment quantities					Clearance limit		Licensing limit	Guidance values		Unstable daughter nuclide
			e_{inh} Sv/Bq	e_{ing} Sv/Bq	h_{10} (mSv/h)/ GBq at 1 m distance	$h_{0.07}$ (mSv/h)/ GBq at 10 cm distance	$h_{c,0.07}$ (mSv/h)/ (kBq/cm^2)	**LL** Bq/g		**LA** Bq	**CA** Bq/m^3	**CS** Bq/ cm^2	
1	2	3	4	5	6	7	8	9		10	11	12	13
Am-238	98 min	ec, β^+, α / ph	6.60E-11	3.20E-11	0.145	60	0.1	1.E+01	[1]	8.00E+07	1.00E+05	100	→ Pu-238, Np-234
Am-239	11.9 h	ec, α / ph	2.90E-10	2.40E-10	0.059	1000	1.4	1.E+02	[1]	2.00E+07	3.00E+04	3	→ Pu-239, Np-235
Am-240	50.8 h	ec, α / ph	5.90E-10	5.80E-10	0.171	50	0.3	1.E+01		8.00E+06	1.00E+04	30	→ Pu-240, Np-236
Am-241	432.2 a	α / ph	2.70E-05	2.00E-07	0.019	6	<0.1	1.E-01		2.00E+02	3.00E-01	1	→ Np-237
Am-242	16.02 h	β^-, ec / ph	1.20E-08	3.00E-10	0.009	1000	1.1	1.E+03		4.00E+05	7.00E+02	3	→ Cm-242, Pu-242
Am-242m	141 a	it, α / ph	2.40E-05	1.90E-07	0.006	2	<0.1	1.E-01	[2]	2.00E+02	3.00E-01	1	→ Am-242, Np-238
Am-243	7.37 E3 a	α / ph	2.70E-05	2.00E-07	0.014	2	<0.1	1.E-01	[2]	2.00E+02	3.00E-01	1	→ Np-239
Am-244	10.1 h	β^- / ph	1.50E-09	4.60E-10	0.145	3000	2.9	1.E+01		3.00E+06	6.00E+03	3	→ Cm-244
Am-244m	26 min	β^- / ph	6.20E-11	2.90E-11	0.002	1000	1.6	1.E+04	[1]	8.00E+07	1.00E+05	3	→ Cm-244
Am-245	2.05 h	β^- / ph	7.60E-11	6.20E-11	0.007	2000	1.8	1.E+03		7.00E+07	1.00E+05	3	→ Cm-245
Am-246	39 min	β^- / ph	1.10E-10	5.80E-11	0.135	4000	4.5	1.E+01	[1]	5.00E+07	8.00E+04	1	→ Cm-246
Am-246m	25.0 min	β^- / ph	3.80E-11	3.40E-11	0.154	1000	1.7	1.E+01	[1]	1.00E+08	2.00E+05	3	→ Cm-246
Cm-238	2.4 h	ec, α / ph	4.80E-09	8.00E-11	0.021	7	<0.1	1.E+02	[1]	1.00E+06	2.00E+03	1000	→ Am-238, Pu-234
Cm-240	27 d	α, fs / ph	2.30E-06	7.60E-09	0.003	<1	<0.1	1.E+02		2.00E+03	4.00E+00	30	→ Pu-236
Cm-241	32.8 d	ec, α / ph	2.60E-08	9.10E-10	0.100	600	0.7	1.E+01		2.00E+05	3.00E+02	10	→ Am-241, Pu-237
Cm-242	162.8 d	α, fs / ph	3.70E-06	1.20E-08	0.002	<1	<0.1	1.E+01		1.00E+03	2.00E+00	10	→ Pu-238
Cm-243	29.1 a	ec / ph	2.00E-05	1.50E-07	0.033	1000	1.1	1.E+00		3.00E+02	4.00E-01	1	→ Pu-239, Am-243
Cm-244	18.10 a	α, fs / ph	1.70E-05	1.20E-07	0.002	<1	<0.1	1.E+00		3.00E+02	5.00E-01	3	→ Pu-240
Cm-245	8.5 E3 a	α, fs / ph	2.70E-05	2.10E-07	0.028	400	0.4	1.E-01		2.00E+02	3.00E-01	1	→ Pu-241
Cm-246 [9]	4.76 E3 a	α, fs / ph	2.70E-05	2.10E-07	0.013	<1	<0.1	1.E-01		2.00E+02	3.00E-01	1	→ Pu-242

Radionuclide	Half-life	Type of decay/ radiation	Assessment quantities					Clearance limit		Licensing limit	Guidance values		Unstable daughter nuclide
			e_{inh} Sv/Bq	e_{ing} Sv/Bq	h_{10} (mSv/h)/ GBq at 1 m distance	$h_{0,07}$ (mSv/h)/ GBq at 10 cm distance	$h_{c,0,07}$ (mSv/h)/ (kBq/cm²)	**LL** Bq/g		**LA** Bq	**CA** Bq/m³	**CS** Bq/ cm²	
1	2	3	4	5	6	7	8	9		10	11	12	13
Cm-247	1.56 E7 a	α / ph	2.50E-05	1.90E-07	0.053	100	0.1	1.E-01	[2]	2.00E+02	3.00E-01	1	→ Pu-243
Cm-248 [9]	3.48 E5 a	α, fs / ph	9.50E-05	7.70E-07	3.8	<1	<0.1	1.E-01		5.00E+01	9.00E-02	0.3	→ Pu-244
Cm-249	64.15 min	β⁻ / ph	5.10E-11	3.10E-11	0.003	1000	1.5	1.E+03		1.00E+08	2.00E+05	3	→ Bk-249
Cm-250 [9]	8300 a	α, β⁻, fs / ph	5.40E-04	4.40E-06	36	<1	<0.1	1.E-02	[2]	9.00E+00	2.00E-02	0.1	→ Pu-246, Bk-250
Bk-245	4.94 d	ec, α / ph	1.80E-09	5.70E-10	0.054	2000	1.6	1.E+02		3.00E+06	5.00E+03	3	→ Cm-245, Am-241
Bk-246	1.80 d	ec / ph	4.60E-10	4.80E-10	0.161	30	0.1	1.E+01	[1]	1.00E+07	2.00E+04	100	→ Cm-246
Bk-247	1.38 E3 a	α / ph	4.50E-05	3.50E-07	0.021	800	0.7	1.E-01		1.00E+02	2.00E-01	1	→ Am-243
Bk-249	330 d	β⁻, α	1.00E-07	9.70E-10	<0.001	20	<0.1	1.E+02		5.00E+04	8.00E+01	300	→ Cf-249, Am-245
Bk-250	3.212 h	β⁻ / ph	7.10E-10	1.40E-10	0.137	1000	1.5	1.E+01	[1]	7.00E+06	1.00E+04	3	→ Cf-250
Cf-244	19.4 min	α / ph	1.80E-08	7.00E-11	0.003	<1	<0.1	1.E+04	[1]	3.00E+05	5.00E+02	1000	→ Cm-240
Cf-246	35.7 h	α, fs / ph	3.50E-07	3.30E-09	0.002	<1	<0.1	1.E+03		1.00E+04	2.00E+01	100	→ Cm-242
Cf-248 [9]	334 d	α, fs / ph	6.10E-06	2.80E-08	0.003	<1	<0.1	1.E+00		8.00E+02	1.00E+00	10	→ Cm-244
Cf-249	351 a	α, fs / ph	4.50E-05	3.50E-07	0.060	200	0.2	1.E-01		1.00E+02	2.00E-01	1	→ Cm-245
Cf-250 [9]	13.08 a	α, fs / ph	2.20E-05	1.60E-07	0.035	<1	<0.1	1.E+00		2.00E+02	4.00E-01	1	→ Cm-246
Cf-251	900 a	α / ph	4.60E-05	3.60E-07	0.037	1000	1.8	1.E-01		1.00E+02	2.00E-01	1	→ Cm-247
Cf-252 [9]	2.645 a	α, fs / ph	1.30E-05	9.00E-08	1.3	<1	<0.1	1.E+00		4.00E+02	6.00E-01	3	→ Cm-248
Cf-253	17.81 d	β⁻, α / ph	1.00E-06	1.40E-09	<0.001	800	0.8	1.E+02	[2]	5.00E+03	8.00E+00	10	→ Es-253, Cm-249
Cf-254 [9]	60.5 d	α, fs / ph	2.20E-05	4.00E-07	42	<1	<0.1	1.E+00		2.00E+02	4.00E-01	1	→ Cm-250
Es-250	8.6 h	ec / ph	4.20E-10	2.10E-11	0.071	20	0.1	1.E+02	[1]	1.00E+07	2.00E+04	100	→ Cf-250
Es-251	33 h	ec, α / ph	1.70E-09	1.70E-10	0.028	200	0.2	1.E+02	[1]	3.00E+06	5.00E+03	30	→ Cf-251, Bk-247
Es-253	20.47 d	α, fs / ph	2.10E-06	6.10E-09	0.001	1	<0.1	1.E+02		2.00E+03	4.00E+00	30	→ Bk-249
Es-254	275.7 d	α, β⁻, fs / ph	6.00E-06	2.80E-08	0.021	6	<0.1	1.E-01	[2]	8.00E+02	1.00E+00	10	→ Bk-250

Radionuclide	Half-life	Type of decay/ radiation	Assessment quantities					Clearance limit		Licensing limit	Guidance values		Unstable daughter nuclide
			e_{inh} Sv/Bq	e_{ing} Sv/Bq	h_{10} (mSv/h)/ GBq at 1 m distance	$h_{0.07}$ (mSv/h)/ GBq at 10 cm distance	$h_{c,0.07}$ (mSv/h)/ (kBq/cm^2)	**LL** Bq/g		**LA** Bq	**CA** Bq/m^3	**CS** Bq/ cm^2	
1	2	3	4	5	6	7	8	9		10	11	12	13
Es-254m	39.3 h	β$^-$, α, ec, fs / ph	3.70E-07	4.20E-09	0.077	1000	1.4	1.E+01	[2]	1.00E+04	2.00E+01	3	→ Fm-254, Bk-250
Fm-252	25.39 h	α, fs / ph	2.60E-07	2.70E-09	0.002	<1	<0.1	1.E+03		2.00E+04	3.00E+01	100	→ Cf-248
Fm-253	3.00 d	ec, α / ph	3.00E-07	9.10E-10	0.023	200	0.2	1.E+02		2.00E+04	3.00E+01	30	→ Es-253, Cf-249
Fm-254	3.240 h	α, fs / ph	7.70E-08	4.40E-10	0.002	<1	<0.1	1.E+04	[1]	6.00E+04	1.00E+02	1000	→ Cf-250
Fm-255	20.07 h	α, fs / ph	2.60E-07	2.50E-09	0.016	5	0.1	1.E+02		2.00E+04	3.00E+01	100	→ Cf-251
Fm-257	100.5 d	α, fs / ph	5.20E-06	1.50E-08	0.032	600	0.8	1.E+01		1.00E+03	2.00E+00	10	→ Cf-253
Md-257	5.2 h		2.00E-08	1.20E-10	0.027	30	<0.1	1.E+02	[1]	3.00E+05	4.00E+02	1000	→ Fm-257, Es-253
Md-258	55 d		4.40E-06	1.30E-08	0.007	2	<0.1	1.E+01		1.00E+03	2.00E+00	10	→ Es-254

Explanatory notes on the individual columns

1–3 General data on the radionuclide [source: International Commission on Radiological Protection, ICRP Publication 107]. Daughter nuclides with a half-life of less than ten minutes are not listed separately. Their properties are included in the row for the parent nuclide.

1 Radionuclide; m: metastable. A daughter nuclide with a half-life of less than ten minutes is given after a slash.

2 Half-life: s, second(s); min, minute(s); h, hour(s); d, day(s); a, year(s); E, exponential notation. Source: International Commission on Radiological Protection, ICRP Publication 107. For individual nuclides not listed therein: IAEA Safety Standards: Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards (BSS), Revision of IAEA Safety Series No. 115, GOV/2011/42, 15 August 2011; Table III.2A.

3 Type of decay/radiation: α, alpha radiation; β^+, β^-, beta radiation; ec, electron capture; it, isomeric transition; sf, spontaneous fission. For «/radiation», «/ph» is given for each radionuclide where decay involves emission of photon radiation (γ or X-rays) with an energy of more than 10^{-4} MeV per decay.

4, 5 Dose coefficient for the committed effective dose resulting from inhalation or ingestion of a radionuclide in adults [source: IAEA Safety Standards: Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards, Revision of IAEA Safety Series No. 115, GOV/2011/42, 15 August 2011; Table III.2A, Column $e(g)_{5\ \mu m}$ for inhalation and Column $e(g)$ for ingestion. For individual nuclides not listed therein: ICRP Database of Dose Coefficients: Workers and Members of the Public, available on the ICRP website under «Free Educational CD Downloads».

4 Dose coefficient for the committed effective dose resulting from inhalation of a radionuclide. The inhalation of 1 Bq yields, at most, the committed effective dose (in Sv) indicated. The value given is the maximum for the various types (or rates) of absorption from the lung into the blood (fast, moderate or slow), with an activity median aerodynamic diameter (AMAD) of 5 µm

Note: For twelve radionuclides [Nb-91, Nb-91m, Nb-92m, Te-119m, Nd-140, Re-183, Pt-190, Au-196, Bi-208, Po-206, Po-208, Po-209] the e_{inh} values are not included either in the IAEA BSS or on the ICRP CD. For the RPO of 22 June 1994[66], the values for these radionuclides were taken from the National Radiological Protection Board report NRPB-R245 (1991). As this source is no longer up to date and these radionuclides are of only minor

66 [AS **1994** 1947, **1995** 4959 No II 2, **1996** 2129, **2000** 107 934 2894, **2001** 3294 No II 7, **2005** 601 Annex 7 No 3 2885 Annex No 7, **2007** 1469 Annex 4 No 44 5651, **2008** 3153 Art. 10 No 2 5747 Annex No 22, **2010** 5191 Art. 20 No 4 5395 Annex 2 No II 3, **2011** 5227 No I 2.7, **2012** 7065 No I 5 7157, **2013** 3041 No I 5 3407 Annex 6 No 3]

importance, dose coefficients are not given for these twelve radionuclides in this Ordinance.

5 Dose coefficient for the committed effective dose resulting from ingestion of a radionuclide. The ingestion of 1 Bq yields, at most, the committed effective dose (in Sv) indicated.

Note: For twelve radionuclides (as for e_{inh}) the e_{ing} values are not included either in the IAEA BSS or on the ICRP CD. For the RPO of 22 June 1994, the values for these radionuclides were taken from the National Radiological Protection Board report NRPB-R245 (1991). As this source is no longer up to date and these radionuclides are of only minor importance, dose coefficients are not given for these twelve radionuclides in this Ordinance.

6–8 Dose coefficient for external radiation [source: Petoussi et al., GSF Report 7/93, National Research Center for Environment and Health, Neuherberg]. If the daughter nuclide has a half-life of less than 10 minutes, the sum of the values for parent and daughter is given.

6 Dose rate at a depth of 10 mm in tissue (ambient dose equivalent rate) at a distance of 1 m from a radioactive source with an activity of 1 GBq (10^9 Bq).

7 Dose rate at a depth of 0.07 mm in tissue (directional dose equivalent rate) at a distance of 10 cm from a radioactive source with an activity of 1 GBq.

8 Dose coefficient for skin contamination. Skin contamination of 1 kBq/cm^2 (averaged over 100 cm^2) yields the dose rate (directional dose equivalent rate) indicated.

9–12 Clearance limit, licensing limit and guidance values

9 Clearance limit for specific activity in Bq/g (LL). [Sources: IAEA, Safety Standards: Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards, Revision of IAEA Safety Series No. 115, GOV/2011/42, 15 August 2011; Table I.2; Brenk Systemplanung, Berechnung von Freigrenzen and Freigabewerten für Nuklide, für die keine Werte in den IAEA-BSS vorliegen, Endbericht, Aachen, 2012.] For radionuclides with a short half-life, the exemption levels calculated in the report by Brenk Systemplanung are often higher than the exemption levels for specific activity which are specified for moderate amounts of material in the IAEA BSS. In such cases, and for the small number of radionuclides for which no value was calculated by Brenk Systemplanung, the values specified for moderate amounts of material in the IAEA BSS are used in this Ordinance [source: IAEA, Safety Standards: Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards, Revision of IAEA Safety Series No. 115, GOV/2011/42, 15 August 2011; Table I.1, Column «Activity concentration»]. Radionuclides for which the exemption levels given for moderate amounts of material in the IAEA BSS are used are marked [1] in Column 9 of the Table.

Radionuclides for which the contribution of daughter nuclides was taken into account in determining the LL value are marked [2] in Column 9 of the Table. The Table below indicates, for each radionuclide for which a daughter nuclide was taken into account, the last radionuclide in the decay chain which was used together with the parent to calculate the LL value.

Example: Ra-226 -> Po-214 means that the daughter nuclides of Ra-226 up to Po-214 (i.e. Rn-222, Po-218, Pb-214, Bi-214 and Po-214) were taken into account, together with the parent, in calculating the clearance level.

For H-3 and S-35, which can occur in various chemical forms, the LL was calculated in the Brenk Systemplanung report using the more pessimistic dose coefficient for each exposure pathway (e.g. in the case of S-35, with e_{ing} for S-35 org. and e_{inh} for S-35 inorg.). The LL values thus determined were applied to all chemical forms of the radionuclide.

10 Licensing limit (LA). The licensing limit values are derived from Column 4 since inhalation is the main risk when radionuclides are handled in the laboratory. The inhalation of activity at the licensing limit on a single occasion yields a committed effective dose of 5 mSv.

For inert gases, C-11, N-13, O-15, F-18 and Cl-38, the licensing limit corresponds to the activity in an enclosed space of 1000 m^3 and a CA concentration as specified in Column 11.

11 Guidance value for chronic airborne activity for occupationally exposed persons (CA). Exposure to an airborne activity concentration CA for 40 hours per week and 50 weeks per year yields a committed effective dose of 20 mSv.

For inhalation: CA [Bq/m^3] = 0.02 Sv / ($e_{inh} \cdot$ 2400 m^3/a).

For inert gases, immersion in a semi-infinite hemispherical cloud for 40 hours per week and 50 weeks per year yields an effective dose of 20 mSv. (The dose coefficients for immersion e_{imm} are taken from ICRP Publication 119 if they are not covered by Guideline ENSI-G14.) In most cases, the CA value relates to the parent nuclide. The exceptional cases where the CA value is given for the daughter nuclide are indicated as such. Also indicated by a footnote are those cases where immersion leads to irradiation of the skin or all organs and where the dose resulting from immersion is greater than that from inhalation. [5]: In the case of Kr-88, values are given for the daughter nuclide for immersion. [3]: Derived from the effective dose for immersion. [4]: Derived from the skin dose for immersion. In this case, the dose coefficients e_{imm} for the skin are taken from the publication: Federal Guidance Report No. 12, External exposure to radionuclides in air, water and soil, Keith F. Eckerman and Jeffrey C. Ryman, Sept. 1993.

12 Guidance value for surface contamination outside of controlled areas, averaged over 100 cm^2 (CS).

The CS value is calculated on the basis of the following scenarios, with the most unfavourable being chosen:

- chronic exposure throughout the year (8760 hours) resulting from skin contamination yields an equivalent dose of 50 mSv per year (1/10 of the dose limit for the skin);
- daily ingestion of contamination on an area of 10 cm^2 yields an effective dose of 0.5 mSv per year;
- a single inhalation of 10% of the activity of contamination on an area of 100 cm^2 yields a dose of 0.5 mSv (1/10 of the licensing limit);
- a maximum value of 1000 Bq/cm^2.

13 Unstable daughter nuclide

13 Unstable daughter nuclide; → means: decays into …; in the case of branching, the different nuclides formed are separated by commas; a second arrow indicates a decay series. [6]: The h_{10} value of the daughter nuclide exceeds 0.1 (mSv/h)/GBq at a distance of 1 m (attention may need to be paid to the daughter nuclide!).

List of footnotes:

[1] Radionuclides for which the values given for moderate amounts of material in the IAEA BSS are used as the clearance limit.

[2] Radionuclides for which the contribution of daughter nuclides was taken into account in determining the LL value (Column 9). The Table below indicates, for each of these radionuclides, the last radionuclide in the decay chain which was used together with the parent to calculate the LL value.

[3] Derived from the effective dose for immersion (Column 11).

[4] Derived from the skin dose for immersion (Column 11).

[5] In the case of Kr-88, values are given for the daughter nuclide for immersion (Column 11).

[6] The h_{10} value of the daughter nuclide exceeds 0.1 (mSv/h)/GBq at a distance of 1 m (attention may need to be paid to the daughter nuclide! Column 13).

[7] The H-3, HTO fraction must also be taken into account.

[8] For Kr-85, LA was chosen so that the dose rate at a distance of 10 cm is 5 μSv/h.

[9] Spontaneous fission is included in h_{10}. The spontaneous fission rate is taken from Table of Isotopes (8th edition, 1996, John Wiley & Sons) and from the ENDF database, Brookhaven National Laboratory. For the average number of neutrons per fission and the dose coefficient, the values for Cf-252 were used. Photons produced during nuclear fission and photons emitted by the resultant fission products are not considered.

[10] Potassium salts in quantities less than 1000 kg are exempted.

[11] For nuclide mixtures of uranium (U-238/U-235/U-234 + daughters) and of thorium (Th-232/Th-230/Th-228 + daughters), the licensing limit of the dominant nuclide applies.

Nuclide mixtures

In the case of nuclide mixtures, the summation rule applies for Columns 9, 11 and 12:

Rule used to assess compliance with activity limits for mixtures of nuclides. Here, the various nuclides are weighted according to the hazard they pose. If the following inequalities are satisfied, then the mixtures are below the clearance limit or below the guidance value for surface contamination.

$$\frac{a_1}{LL_1} + \frac{a_2}{LL_2} + \ldots + \frac{a_n}{LL_n} < 1$$

a_1, a_2, ... a_n: specific activities of nuclides 1, 2, ..., n in Bq/g.

LL_1, LL_2, ... LL_n : clearance limits for nuclides 1, 2, ..., n in Bq/g as specified in Annex 3 Column 9.

$$\frac{c_1}{CS_1} + \frac{c_2}{CS_2} + \ldots + \frac{c_n}{CS_n} < 1$$

c_1, c_2, ... c_n : contamination values for nuclides 1, 2, ..., n in Bq/cm^2.

CS_1, CS_2, ... CS_n: Guidance values for surface contamination for nuclides 1, 2, ..., n in Bq/cm^2 as specified in Annex 3 Column 12.

For Footnote [2]: Daughter nuclides taken into account in calculating the clearance limit

Nuclide	Daughter nuclides	Nuclide	Daughter nuclides	Nuclide	Daughter nuclides	Nuclide	Daughter nuclides	Nuclide	Daughter nuclides
Mg-28	-> Al-28	Mo-99	-> Tc-99m	I-135	-> Xe-135m	Hg-195m	-> Hg-195	Np-237	-> Pa-233
Si-32	-> P-32	Tc-95m	-> Tc-95	Cs-137	-> Ba-137m	Pb-202	-> Tl-202	Pu-239	-> U-235m
Ca-45	-> Sc-45m	Ru-103	-> Rh-103m	Ba-128	-> Cs-128	Pb-210	-> Bi-210	Pu-244	-> Np-240
Sc-44m	-> Sc-44	Ru-106	-> Rh-106	Ce-134	-> La-134	Pb-212	-> Tl-208	Pu-245	-> Am-245
Ti-44	-> Sc-44	Pd-100	-> Rh-100	Ce-137m	-> Ce-137	Bi-210m	-> Tl-206	Pu-246	-> Am-246m
Fe-52	-> Mn-52m	Pd-109	-> Ag-109m	Ce-144	-> Pr-144	At-211	-> Po-211	Am-242m	-> Np-238
Fe-60	-> Co-60	Ag-108m	-> Ag-108	Nd-138	-> Pr-138	Rn-222	-> Tl-210	Am-243	-> Np-239
Ni-66	-> Cu-66	Ag-110m	-> Ag-110	Nd-140	-> Pr-140	Fr-222	-> Po-214	Cm-247	-> Pu-243
Zn-62	-> Cu-62	Cd-109	-> Ag-109m	Gd-146	-> Eu-146	Ra-223	-> Tl-207	Cm-250	-> Am-246m
Zn-69m	-> Zn-69	Cd-113m	-> In-113m	Yb-178	-> Lu-178	Ra-224	-> Tl-208	Cf-253	-> Cm-249
Zn-72	-> Ga-72m	Cd-115	-> In-115m	Lu-177m	-> Lu-177	Ra-226	-> Po-214		
Ge-68	-> Ga-68	Cd-115m	-> In-115m	Hf-172	-> Sn-121m	Ra-228	-> Ac-228		
As-73	-> Ge-73m	In-111	-> Cd-111m	Hf-182	-> Ta-182	Ac-225	-> Pb-209		
Br-80m	-> Br-80	In-114m	-> In-114	W-188	-> Re-188	Ac-226	-> Th-226		
Br-83	-> Kr-83m	Sn-110	-> In-110m	Re-186m	-> Re-186	Ac-227	-> Bi-211		
Rb-83	-> Kr-83m	Sn-113	-> In-113m	Re-189	-> Os-189m	Th-228	-> Tl-208		
Sr-80	-> Rb-80	Sn-121m	-> Sn-121	Os-191	-> Ir-191m	Th-229	-> Pb-209		
Sr-89	-> Y-89m	Sn-126	-> Sb-126	Os-194	-> Ir-194	Th-232	-> Tl-208		
Sr-90	-> Y-90	Sb-125	-> Te-125m	Ir-189	-> Os-189m	Th-234	-> Pa-234		
Sr-91	-> Y-91m	Sb-127	-> Te-127	Ir-190	-> Os-190m	U-230	-> Po-214		
Y-87	-> Sr-87m	Te-127m	-> Te-127	Ir-194m	-> Ir-194	U-232	-> Tl-208		
Zr-86	-> Y-86m	Te-129m	-> Te-129	Pt-191	-> Ir-191m	U-235	-> Th-231		

Nuclide	Daughter nuclides	Nuclide	Daughter nuclides	Nuclide	Daughter nuclides	Nuclide	Daughter nuclides	Nuclide	Daughter nuclides
Zr-95	-> Nb-95m	Te-131m	-> Te-131	Pt-200	-> Au-200	U-238	-> Pa-234		
Zr-97	-> Nb-97	Te-132	-> I-132	Hg-194	-> Au-194	U-240	-> Np-240		

Annex 4
(Art. 2 para. 2 let. b, Art. 22, Art. 61 para. 1 and Art. 194 para. 3)

Dose quantities and method for determination of the radiation dose

1 Dose quantities

1.1 Absorbed dose, D

The fundamental dose quantity given by:

$$D = \frac{d\bar{\varepsilon}}{dm}$$

where $d\bar{\varepsilon}$ is the mean energy imparted to matter of mass dm by ionising radiation. The SI unit for absorbed dose is joule per kilogram (J/kg), and its special name is gray (Gy).

1.2 Mean absorbed dose in a tissue or organ, D_T

The absorbed dose D_T, averaged over the tissue or organ T, which is given by:

$$D_T = \frac{\varepsilon_T}{m_T}$$

where ε_T is the mean total energy imparted in a tissue or organ T, and m_T is the mass of that tissue or organ.

1.3 Equivalent dose, H_T

The dose in a tissue or organ T given by:

$$H_T = \sum_R w_R D_{T,R}$$

where $D_{T,R}$ is the mean absorbed dose from radiation R in a tissue or organ T, and w_R is the radiation weighting factor. Since w_R is dimensionless, the unit for the equivalent dose is the same as for absorbed dose, J/kg. Its special name is sievert (Sv).

1.4 Radiation weighting factors

Radiation type and energy range		Radiation weighting factor, w_R
Photons, all energies		1
Electrons and muons, all energies		1
Neutrons, energy	– under 1 MeV	$2{,}5+18{,}2 \cdot e^{-[\ln(E)]^2/6}$
	– 1 MeV–50 MeV	$5{,}0+17{,}0 \cdot e^{-[\ln(2 \cdot E)]^2/6}$
	– over 50 MeV	$2{,}5+3{,}25 \cdot e^{-[\ln(0{,}04 \cdot E)]^2/6}$
Protons and charged pions		2
Alpha particles, fission fragments, heavy nuclei		20

1.5 Committed equivalent dose, $H_T(\tau)$

The time integral of the equivalent dose rate in a particular tissue or organ that will be received following intake of radioactive material into the body by a Reference Person, where τ is the integration time in years.

1.6 Effective dose, E

The tissue-weighted sum of the equivalent doses in all specified tissues and organs of the body, given by the expression:

$$E = \sum_T w_T \sum_R w_R D_{T,R} = \sum_T w_T H_T$$

where H_T or $w_R D_{T.R}$ is the equivalent dose in a tissue or organ T and w_T is the tissue weighting factor. The unit for the effective dose is the same as for absorbed dose, J/kg, and its special name is sievert (Sv).

1.7 Tissue weighting factors

Tissue or organ	Tissue weighting factor, w_T
Bone-marrow (red)	0.12
Colon	0.12
Lung	0.12
Stomach	0.12
Breast	0.12
Gonads	0.08
Bladder	0.04
Liver	0.04
Oesophagus	0.04

Tissue or organ	Tissue weighting factor, w_T
Thyroid	0.04
Brain	0.01
Skin	0.01
Bone surface	0.01
Salivary glands	0.01
Remainder tissues	0.12

1.8 Committed effective dose, $E(\tau)$

The sum of the products of the committed organ or tissue equivalent doses and the appropriate tissue weighting factors (w_T), where τ is the integration time in years following the intake. The commitment period is taken to be 50 years for adults, and up to age 70 years for children.

1.9 Dose equivalent, H

1.9.1 The product of D and Q at a point in tissue, where D is the absorbed dose and Q is the quality factor for the specific radiation at this point, thus:

$$H = DQ$$

1.9.2 The unit of dose equivalent is joule per kilogram (J/kg), and its special name is sievert (Sv). For the relevant operational quantities, see personal dose equivalent and ambient dose equivalent.

1.10 Ambient dose

The dose equivalent measured at a specific location. The quantities ambient dose equivalent $H^*(10)$ and directional dose equivalent $H'(d, \Omega)$ are taken to be the ambient dose.

1.11 Personal dose equivalent, $H_p(d)$

1.11.1 One dose equivalent: the dose equivalent in soft tissue (commonly interpreted as the «ICRU sphere») at an appropriate depth, d [mm], below a specified point on the human body, usually given by the position where the individual's dosimeter is worn. The unit of personal dose equivalent is joule per kilogram (J/kg), and its special name is sievert (Sv).

1.11.2 The personal dose equivalent $H_p(10)$ is used as an estimate of the effective dose. The personal dose equivalent $H_p(0.07)$ is used as an estimate of the dose to the skin and to the lens of the eye. Alternatively, the personal dose

equivalent $H_p(3)$ may be used as an estimate of the dose to the lens of the eye.

1.12 Directional dose equivalent, $H'(d, \Omega)$

1.12.1 The dose equivalent at a point in a radiation field that would be produced by the corresponding expanded field in the ICRU sphere at a depth, d, on a radius in a specified direction, Ω. The unit of directional dose equivalent is joule per kilogram (J/kg), and its special name is sievert (Sv).

1.12.2 In the particular case of a unidirectional field, the direction can be specified in terms of the angle α between the radius opposing the incident field and the specified radius Ω. If $\alpha = 0°$, the quantity $H'(d, 0°)$ may be written as $H'(d)$ and is equal to $H^*(d)$.

1.12.3 The recommended values for d are 10 mm for penetrating radiation, 0.07 mm for low-penetrating radiation and 3 mm for the lens of the eye (see **operational quantities for area monitoring**).

1.13 Ambient dose equivalent, $H^*(10)$

The dose equivalent at a point in a radiation field that would be produced by the corresponding expanded and aligned field in the ICRU sphere at a depth of 10 mm on the radius vector opposing the direction of the aligned field. The unit of ambient dose equivalent is joule per kilogram (J/kg), and its special name is sievert (Sv).

1.14 ICRU sphere

A sphere of tissue-equivalent material, 30 cm in diameter, with a density of 1 g/cm^3 and a mass composition of 76.2% oxygen, 11.1% carbon, 10.1% hydrogen and 2.6% nitrogen.

1.15 Quality factor, $Q(L)$

1.15.1 The factor characterising the biological effectiveness of a radiation, based on the ionisation density along the tracks of charged particles in tissue. Q is defined as a function of the unrestricted linear energy transfer, LET (L in keV/µm), of charged particles in water:

$$Q(L) = \begin{cases} 1 & \text{für} \quad L < 10 \\ 0.32L - 2.2 & \text{für} \quad 10 \leq L \leq 100 \\ 300/\sqrt{L} & \text{für} \quad L > 100 \end{cases}$$

1.15.2 Q has been superseded by the radiation weighting factor, w_R, in the definition of equivalent dose, but it is still used in calculating the operational dose equivalent quantities used in monitoring.

2 Method for determination of the radiation dose

2.1 Principle

The effective dose and equivalent doses are generally determined using operational quantities.

2.2 Operational quantities

2.2.1 The operational quantities for individual monitoring of external exposure are:

a. the personal dose equivalent $H_p(10)$, with the short form H_p;

b. the personal dose equivalent $H_p(0.07)$, with the short form H_s;

c. the personal dose equivalent $H_p(3)$.

2.2.2 The operational quantities for area monitoring are:

a. the ambient dose equivalent $H^*(10)$;

b. the directional dose equivalent $H'(0.07)$;

c. the directional dose equivalent $H'(3)$.

2.2.3 The operational quantity for internal exposure is the committed effective dose E_{50}, calculated using standard models and the dose coefficients specified in Annexes 3 and 6.

2.3 Personal doses and ambient doses below the relevant dose limits

2.3.1 In situations of external exposure, the equivalent dose for organs is taken to be equal to the personal dose equivalent $H_p(10)$, or to the ambient dose equivalent $H^*(10)$, for all tissues and organs apart from the skin and the lens of the eye.

2.3.2 In situations of external exposure, the equivalent dose for the skin, hands and feet is taken to be equal to the personal dose equivalent $H_p(0.07)$, or to the directional dose equivalent $H'(0.07)$.

2.3.3 In situations of external exposure, the equivalent dose for the lens of the eye is taken to be equal to the personal dose equivalent $H_p(0.07)$, or to the directional dose equivalent $H'(0.07)$. Alternatively, it may also be taken to be equal to the personal dose equivalent $H_p(3)$, or to the directional dose equivalent $H'(3)$.

2.3.4 The effective dose is taken to be equal to the sum of:

a. the personal dose equivalent $H_p(10)$, or the ambient dose equivalent $H^*(10)$; and

b. the committed effective dose E_{50}.

2.4 Personal doses above the relevant dose limits

If the dose values determined in accordance with point 2.3 are above the relevant limits, then the effective dose or equivalent doses for the person concerned must be individually determined by a radiological protection expert, in cooperation with the supervisory authority, using calculation methods and dose coefficients in accordance with the current state of science and technology. The value thus determined is decisive in establishing whether or not a dose limit has been exceeded.

2.5 Area monitoring

Where ambient dose limits are specified by this Ordinance, the ambient dose is taken to be:

a. the quantity $H^*(10)$ (ambient dose equivalent) for penetrating radiation;

b. the quantity $H'(0.07)$ (directional dose equivalent) for low-penetrating radiation.

Annex 5
(Art. 139 para. 2 and 194 para. 3)

Dose coefficients for members of the public

1. Inhalation

Nuclide	Absorption class	Infant (1 year)			Child (10 years)			Adult		
	Type	e_{inh} Sv/Bq	$h_{inh, Organ}$ Sv/Bq	**Organ**	e_{inh} Sv/Bq	$h_{inh, Organ}$ Sv/Bq	**Organ**	e_{inh} Sv/Bq	$h_{inh, Organ}$ Sv/Bq	**Organ**
H-3, HTO [1]	V	4.8 E-11	4.8 E-11	GK	2.3 E-11	2.3 E-11	GK	1.8 E-11	1.8 E-11	GK
H-3, OBT [2]	V	1.1 E-10	1.1 E-10	GK	5.5 E-11	5.5 E-11	GK	4.1 E-11	4.1 E-11	GK
C-14 organisch	V	1.6 E-09	1.6 E-09	GK	7.9 E-10	7.9 E-10	GK	5.8 E-10	5.8 E-10	GK
Na-22	F	7.3 E-09	6.4 E-08	ET	2.4 E-09	2.0 E-08	ET	1.3 E-09	9.2 E-09	ET
Na-24	F	1.8 E-09	4.3 E-08	ET	5.7 E-10	1.3 E-08	ET	2.7 E-10	6.0 E-09	ET
Sc-47	F	2.8 E-09	1.4 E-08	Lu	1.1 E-09	6.7 E-09	Lu	7.3 E-10	5.1 E-09	Lu
Cr-51	M	1.9 E-10	8.2 E-10	ET	6.4 E-11	2.6 E-10	ET	3.2 E-11	1.4 E-10	Lu
Mn-54	M	6.2 E-09	2.5 E-08	ET	2.4 E-09	9.1 E-09	Lu	1.5 E-09	6.3 E-09	Lu
Fe-59	M	1.3 E-08	6.7 E-08	Lu	5.5 E-09	3.1 E-08	Lu	3.7 E-09	2.3 E-08	Lu
Co-57	M	2.2 E-09	1.2 E-08	Lu	8.5 E-10	4.8 E-09	Lu	5.5 E-10	3.3 E-09	Lu
Co-58	M	6.5 E-09	3.0 E-08	ET	2.4 E-09	1.2 E-08	Lu	1.6 E-09	8.9 E-09	Lu
Co-60	M	3.4 E-08	1.6 E-07	Lu	1.5 E-08	7.3 E-08	Lu	1.0 E-08	5.2 E-08	Lu
Zn-65	M	6.5 E-09	1.9 E-08	ET	2.4 E-09	7.5 E-09	Lu	1.6 E-09	5.1 E-09	Lu
Se-75	F	6.0 E-09	2.4 E-08	Ni	2.5 E-09	9.2 E-09	Ni	1.0 E-09	5.4 E-09	Ni
Br-82	M	3.0 E-09	5.0 E-08	ET	1.1 E-09	1.5 E-08	ET	6.3 E-10	7.0 E-09	ET
Sr-89	M	2.4 E-08	1.5 E-07	Lu	9.1 E-09	6.3 E-08	Lu	6.1 E-09	4.5 E-08	Lu
Sr-90	M	1.1 E-07	7.0 E-07	Lu	5.1 E-08	2.9 E-07	Lu	3.6 E-08	2.1 E-07	Lu
Y-91	M	3.0 E-08	1.7 E-07	Lu	1.1 E-08	6.9 E-08	Lu	7.1 E-09	5.0 E-08	Lu
Zr-95	M	1.6 E-08	9.1 E-08	Lu	6.8 E-09	4.2 E-08	Lu	4.8 E-09	3.1 E-08	Lu
Nb-95	M	5.2 E-09	2.8 E-08	Lu	2.2 E-09	1.3 E-08	Lu	1.5 E-09	9.5 E-09	Lu
Mo-99	M	4.4 E-09	1.8 E-08	DD	1.5 E-09	7.2 E-09	Lu	8.9 E-10	5.3 E-09	Lu
Tc-99m	M	9.9 E-11	1.4 E-09	ET	3.4 E-11	4.3 E-10	ET	1.9 E-11	2.1 E-10	ET
Ru-103	M	8.4 E-09	5.3 E-08	Lu	3.5 E-09	2.4 E-08	Lu	2.4 E-09	1.8 E-08	Lu

Nuclide	Absorption class	Infant (1 year)			Child (10 years)			Adult		
	Type	e_{inh} Sv/Bq	$h_{inh, Organ}$ Sv/Bq	**Organ**	e_{inh} Sv/Bq	$h_{inh, Organ}$ Sv/Bq	**Organ**	e_{inh} Sv/Bq	$h_{inh, Organ}$ Sv/Bq	**Organ**
Ru-106	M	1.1 E-07	7.1 E-07	Lu	4.1 E-08	2.8 E-07	Lu	2.8 E-08	2.0 E-07	Lu
Ag-110m	M	2.8 E-08	1.1 E-07	Lu	1.2 E-08	5.1 E-08	Lu	7.6 E-09	3.6 E-08	Lu
Sn-125	M	1.5 E-08	6.5 E-08	Lu	5.0 E-09	2.7 E-08	Lu	3.1 E-09	2.0 E-08	Lu
Sb-122	M	5.7 E-09	2.7 E-08	DD	1.8 E-09	7.5 E-09	Lu	1.0 E-09	5.5 E-09	Lu
Sb-124	M	2.4 E-08	1.4 E-07	Lu	9.6 E-09	6.1 E-08	Lu	6.4 E-09	4.4 E-08	Lu
Sb-125	M	1.6 E-08	1.0 E-07	Lu	6.8 E-09	4.5 E-08	Lu	4.8 E-09	3.2 E-08	Lu
Sb-127	M	7.3 E-09	3.1 E-08	Lu	2.7 E-09	1.4 E-08	Lu	1.7 E-09	1.1 E-08	Lu
Te-125m	M	1.1 E-08	7.4 E-08	Lu	4.8 E-09	3.5 E-08	Lu	3.4 E-09	2.6 E-08	Lu
Te-127m	M	2.6 E-08	1.7 E-07	Lu	1.1 E-08	7.7 E-08	Lu	7.4 E-09	5.6 E-08	Lu
Te-129m	M	2.6 E-08	1.5 E-07	Lu	9.8 E-09	6.6 E-08	Lu	6.6 E-09	4.8 E-08	Lu
Te-131m	M	5.8 E-09	3.2 E-08	ET	1.9 E-09	9.8 E-09	ET	9.4 E-10	4.6 E-09	Lu
Te-132	M	1.3 E-08	5.6 E-08	ET	4.0 E-09	1.7 E-08	ET	2.0 E-09	1.0 E-08	Lu
I-125	F	2.3 E-08	4.5 E-07	SD	1.1 E-08	2.2 E-07	SD	5.1 E-09	1.0 E-07	SD
I-125 organisch	V	4.0 E-08	8.1 E-07	SD	2.2 E-08	4.4 E-07	SD	1.1 E-08	2.1 E-07	SD
I-125 elementar	V	5.2 E-08	1.0 E-06	SD	2.8 E-08	5.6 E-07	SD	1.4 E-08	2.7 E-07	SD
I-129	F	8.6 E-08	1.7 E-06	SD	6.7 E-08	1.3 E-06	SD	3.6 E-08	7.1 E-07	SD
I-129 organisch	V	1.5 E-07	3.0 E-06	SD	1.3 E-07	2.7 E-06	SD	7.4 E-08	1.5 E-06	SD
I-129 elementar	V	2.0 E-07	3.9 E-06	SD	1.7 E-07	3.4 E-06	SD	9.6 E-08	1.9 E-06	SD
I-131	F	7.2 E-08	1.4 E-06	SD	1.9 E-08	3.7 E-07	SD	7.4 E-09	1.5 E-07	SD
I-131 organisch	V	1.3 E-07	2.5 E-06	SD	3.7 E-08	7.4 E-07	SD	1.5 E-08	3.1 E-07	SD
I-131 elementar	V	1.6 E-07	3.2 E-06	SD	4.8 E-08	9.5 E-07	SD	2.0 E-08	3.9 E-07	SD
I-133	F	1.8 E-08	3.5 E-07	SD	3.8 E-09	7.4 E-08	SD	1.5 E-09	2.8 E-08	SD
I-133 organisch	V	3.2 E-08	6.3 E-07	SD	7.6 E-09	1.5 E-07	SD	3.1 E-09	6.0 E-08	SD
I-133 elementar	V	4.1 E-08	8.0 E-07	SD	9.7 E-09	1.9 E-07	SD	4.0 E-09	7.6 E-08	SD
I-135	F	3.7 E-09	7.0 E-08	SD	7.9 E-10	1.5 E-08	SD	3.2 E-10	5.7 E-09	SD
I-135 organisch	V	6.7 E-09	1.3 E-07	SD	1.6 E-09	3.1 E-08	SD	6.8 E-10	1.3 E-08	SD
I-135 elementar	V	8.5 E-09	1.6 E-07	SD	2.1 E-09	3.8 E-08	SD	9.2 E-10	1.5 E-08	SD
Cs-134	F	7.3 E-09	4.9 E-08	ET	5.3 E-09	1.8 E-08	ET	6.6 E-09	1.2 E-08	ET
Cs-136	F	5.2 E-09	5.9 E-08	ET	2.0 E-09	1.9 E-08	ET	1.2 E-09	8.8 E-09	ET
Cs-137 / Ba-137m	F	5.4 E-09	2.5 E-08	ET	3.7 E-09	9.7 E-09	ET	4.6 E-09	7.4 E-09	ET
Ba-140	M	2.0 E-08	1.1 E-07	Lu	7.6 E-09	4.8 E-08	Lu	5.1 E-09	3.5 E-08	Lu
La-140	M	6.3 E-09	4.4 E-08	ET	2.0 E-09	1.3 E-08	ET	1.1 E-09	6.2 E-09	ET

Nuclide	Absorption class	Infant (1 year)			Child (10 years)			Adult		
	Type	e_{inh} Sv/Bq	$h_{inh, Organ}$ Sv/Bq	**Organ**	e_{inh} Sv/Bq	$h_{inh, Organ}$ Sv/Bq	**Organ**	e_{inh} Sv/Bq	$h_{inh, Organ}$ Sv/Bq	**Organ**
Ce-141	M	1.1 E-08	6.9 E-08	Lu	4.6 E-09	3.2 E-08	Lu	3.2 E-09	2.4 E-08	Lu
Ce-144	M	1.6 E-07	6.5 E-07	Lu	5.5 E-08	2.6 E-07	Lu	3.6 E-08	1.9 E-07	Lu
Pr-143	M	8.4 E-09	4.6 E-08	Lu	3.2 E-09	2.1 E-08	Lu	2.2 E-09	1.5 E-08	Lu
Pb-210	M	3.7 E-06	2.2 E-05	Lu	1.5 E-06	1.1 E-05	KH	1.1 E-06	1.3 E-05	KH
Bi-210	M	3.0 E-07	2.4 E-06	Lu	1.3 E-07	1.1 E-06	Lu	9.3 E-08	7.7 E-07	Lu
Po-210	M	1.1 E-05	8.1 E-05	Lu	4.6 E-06	3.5 E-05	Lu	3.3 E-06	2.6 E-05	Lu
Ra-224	M	8.2 E-06	6.7 E-05	Lu	3.9 E-06	3.2 E-05	Lu	3.0 E-06	2.5 E-05	Lu
Ra-226	M	1.1 E-05	9.1 E-05	Lu	4.9 E-06	3.8 E-05	Lu	3.5 E-06	2.8 E-05	Lu
Th-227	S	3.0 E-05	2.5 E-04	Lu	1.4 E-05	1.2 E-04	Lu	1.0 E-05	8.7 E-05	Lu
Th-228	S	1.3 E-04	1.1 E-03	Lu	5.5 E-05	4.5 E-04	Lu	4.0 E-05	3.3 E-04	Lu
Th-230	S	3.5 E-05	2.6 E-04	KH	1.6 E-05	2.4 E-04	KH	1.4 E-05	2.8 E-04	KH
Th-232	S	5.0 E-05	3.5 E-04	Lu	2.6 E-05	2.6 E-04	KH	2.5 E-05	2.9 E-04	KH
Pa-231	M	2.3 E-04	1.0 E-02	KH	1.5 E-04	7.5 E-03	KH	1.4 E-04	6.8 E-03	KH
U-234	M	1.1 E-05	9.0 E-05	Lu	4.8 E-06	3.8 E-05	Lu	3.5 E-06	2.7 E-05	Lu
U-235	M	1.0 E-05	8.1 E-05	Lu	4.3 E-06	3.4 E-05	Lu	3.1 E-06	2.4 E-05	Lu
U-238	M	9.4 E-06	7.5 E-05	Lu	4.0 E-06	3.1 E-05	Lu	2.9 E-06	2.2 E-05	Lu
Np-237	M	4.0 E-05	8.3 E-04	KH	2.2 E-05	6.7 E-04	KH	2.3 E-05	1.0 E-03	KH
Np-239	M	4.2 E-09	1.8 E-08	ET	1.4 E-09	8.4 E-09	Lu	9.3 E-10	6.3 E-09	Lu
Pu-238	M	7.4 E-05	1.2 E-03	KH	4.4 E-05	9.8 E-04	KH	4.6 E-05	1.4 E-03	KH
Pu-239	M	7.7 E-05	1.3 E-03	KH	4.8 E-05	1.1 E-03	KH	5.0 E-05	1.5 E-03	KH
Pu-240	M	7.7 E-05	1.3 E-03	KH	4.8 E-05	1.1 E-03	KH	5.0 E-05	1.5 E-03	KH
Pu-241	M	9.7 E-07	2.2 E-05	KH	8.3 E-07	2.4 E-05	KH	9.0 E-07	3.1 E-05	KH
Am-241	M	6.9 E-05	1.4 E-03	KH	4.0 E-05	1.2 E-03	KH	4.2 E-05	1.7 E-03	KH
Cm-242	M	1.8 E-05	1.2 E-04	KH	7.3 E-06	4.8 E-05	Lu	5.2 E-06	3.5 E-05	Lu
Cm-244	M	5.7 E-05	9.6 E-04	KH	2.7 E-05	6.4 E-04	KH	2.7 E-05	9.2 E-04	KH

Absorption class The absorption class indicates the rate at which an inhaled substance is absorbed from the lung into the blood. Type F: fast, Type M: moderate, Type S: slow, Type V: very rapid/instantaneous (only applies to certain gases and vapours)

e_{inh}: Committed effective dose; integration period: 50 years for adults, 70 years for children
Dose coefficients taken from: ICRP, 2012. Compendium of Dose Coefficients based on ICRP Publication 60. ICRP Publication 119. Ann. ICRP 41(Suppl.). Tables G.1 and H.1 (AMAD = 1µm)
Dose coefficients for other nuclides and for other age categories can be found in ICRP Publication 119.

$h_{inh,\ Organ}$:	Committed dose in the most affected organ [WB: whole body, Go: gonads, BM: bone marrow (red), Co: colon, Lu: lung, St: stomach, Bl: bladder, Br: breast, Li: liver, Oe: oesophagus, Th: thyroid, Sk: skin, BS: bone surface, remainder (ET: extrathoracic airways, Ut: uterus, Ki: kidney, Sp: spleen)] Dose coefficients taken from: ICRP Database of Dose Coefficients: Workers and Members of the Public; Ver. 3.0 – Free Educational CD Downloads (AMAD = 1 µm)
[1]	Tritiated water vapour
[2]	Organically bound tritium

2. Ingestion

Nuclide	Infant (1a)			Child (10a)			Adult		
	e_{ing} Sv/Bq	$h_{ing,\ Organ}$ Sv/Bq	**Organ**	e_{ing} Sv/Bq	$h_{ing,\ Organ}$ Sv/Bq	**Organ**	e_{ing} Sv/Bq	$h_{ing,\ Organ}$ Sv/Bq	**Organ**
H-3, HTO	4.8E-11	4.8E-11	GK	2.3E-11	2.3E-11	GK	1.8E-11	1.8E-11	GK
H-3, OBT [2]	1.2E-10	1.6E-10	Ma	5.7E-11	6.7E-11	Ma	4.2E-11	4.7E-11	Ma
C-14	1.6E-09	1.9E-09	Ma	8.0E-10	8.9E-10	Ma	5.8E-10	6.3E-10	Ma
Na-22	1.5E-08	2.8E-08	KH	5.5E-09	1.1E-08	KH	3.2E-09	6.3E-09	KH
Na-24	2.3E-09	6.7E-09	Ma	7.7E-10	2.1E-09	Ma	4.3E-10	1.2E-09	Ma
Sc-47	3.9E-09	3.0E-08	DD	1.2E-09	9.0E-09	DD	5.4E-10	4.1E-09	DD
Cr-51	2.3E-10	1.4E-09	DD	7.8E-11	4.5E-10	DD	3.8E-11	2.1E-10	DD
Mn-54	3.1E-09	8.3E-09	DD	1.3E-09	3.3E-09	DD	7.1E-10	1.8E-09	DD
Fe-59	1.3E-08	3.5E-08	DD	4.7E-09	1.2E-08	DD	1.8E-09	5.8E-09	DD
Co-57	1.6E-09	5.6E-09	DD	5.8E-10	1.8E-09	DD	2.1E-10	9.4E-10	DD
Co-58	4.4E-09	1.4E-08	DD	1.7E-09	4.9E-09	DD	7.4E-10	2.8E-09	DD
Co-60	2.7E-08	5.1E-08	DD	1.1E-08	2.0E-08	Le	3.4E-09	8.7E-09	DD
Zn-65	1.6E-08	2.2E-08	KH	6.4E-09	8.9E-09	KH	3.9E-09	5.4E-09	KH
Se-75	1.3E-08	5.1E-08	Ni	6.0E-09	2.2E-08	Ni	2.6E-09	1.4E-08	Ni
Br-82	2.6E-09	4.0E-09	DD	9.5E-10	1.5E-09	DD	5.4E-10	8.3E-10	Ma
Sr-89	1.8E-08	9.2E-08	DD	5.8E-09	2.7E-08	DD	2.6E-09	1.4E-08	DD
Sr-90	7.3E-08	7.3E-07	KH	6.0E-08	1.0E-06	KH	2.8E-08	4.1E-07	KH
Y-91	1.8E-08	1.4E-07	DD	5.2E-09	4.2E-08	DD	2.4E-09	1.9E-08	DD
Zr-95	5.6E-09	3.4E-08	DD	1.9E-09	1.1E-08	DD	9.5E-10	5.1E-09	DD

Nuclide	Infant (1a)			Child (10a)			Adult		
	e_{ing} Sv/Bq	$h_{ing,\ Organ}$ Sv/Bq	**Organ**	e_{ing} Sv/Bq	$h_{ing,\ Organ}$ Sv/Bq	**Organ**	e_{ing} Sv/Bq	$h_{ing,\ Organ}$ Sv/Bq	**Organ**
Nb-95	3.2E-09	1.6E-08	DD	1.1E-09	5.6E-09	DD	5.8E-10	2.8E-09	DD
Mo-99	3.5E-09	1.6E-08	Le	1.1E-09	5.5E-09	Le/Ni	6.0E-10	3.1E-09	Ni
Tc-99m	1.3E-10	4.7E-10	SD	4.3E-11	1.4E-10	DD	2.2E-11	6.7E-11	DD
Ru-103	4.6E-09	2.9E-08	DD	1.5E-09	9.2E-09	DD	7.3E-10	4.3E-09	DD
Ru-106	4.9E-08	3.3E-07	DD	1.5E-08	1.0E-07	DD	7.0E-09	4.5E-08	DD
Ag-110m	1.4E-08	4.6E-08	DD	5.2E-09	1.7E-08	DD	2.8E-09	8.5E-09	DD
Sn-125	2.2E-08	1.8E-07	DD	6.7E-09	5.2E-08	DD	3.1E-09	2.4E-08	DD
Sb-122	1.2E-08	9.1E-08	DD	3.7E-09	2.7E-08	DD	1.7E-09	1.2E-08	DD
Sb-124	1.6E-08	9.6E-08	DD	5.2E-09	3.0E-08	DD	2.5E-09	1.4E-08	DD
Sb-125	6.1E-09	3.3E-08	KH	2.1E-09	1.3E-08	KH	1.1E-09	9.0E-09	KH
Sb-127	1.2E-08	8.4E-08	DD	3.6E-09	2.5E-08	DD	1.7E-09	1.2E-08	DD
Te-125m	6.3E-09	9.0E-08	KH	1.9E-09	3.4E-08	KH	8.7E-10	2.0E-08	KH
Te-127m	1.8E-08	1.4E-07	KH	5.2E-09	5.5E-08	KH	2.3E-09	3.2E-08	KH
Te-129m	2.4E-08	1.1E-07	DD	6.6E-09	3.2E-08	DD	3.0E-09	1.4E-08	DD
Te-131m	1.4E-08	1.5E-07	SD	4.3E-09	4.5E-08	SD	1.9E-09	1.8E-08	SD
Te-132	3.0E-08	3.2E-07	SD	8.3E-09	7.5E-08	SD	3.8E-09	3.1E-08	SD
I-125	5.7E-08	1.1E-06	SD	3.1E-08	6.2E-07	SD	1.5E-08	3.0E-07	SD
I-129	2.2E-07	4.3E-06	SD	1.9E-07	3.8E-06	SD	1.1E-07	2.1E-06	SD
I-131	1.8E-07	3.6E-06	SD	5.2E-08	1.0E-06	SD	2.2E-08	4.3E-07	SD
I-133	4.4E-08	8.6E-07	SD	1.0E-08	2.0E-07	SD	4.3E-09	8.2E-08	SD
I-135	8.9E-09	1.7E-07	SD	2.2E-09	3.9E-08	SD	9.3E-10	1.6E-08	SD
Cs-134	1.6E-08	2.4E-08	DD	1.4E-08	1.7E-08	DD	1.9E-08	2.1E-08	DD
Cs-136	9.5E-09	1.3E-08	DD	4.4E-09	5.3E-09	DD	3.0E-09	3.4E-09	DD
Cs-137 / Ba-137m	1.2E-08	2.3E-08	DD	1.0E-08	1.3E-08	DD	1.3E-08	1.5E-08	DD
Ba-140	1.8E-08	1.2E-07	DD	5.8E-09	3.5E-08	DD	2.6E-09	1.7E-08	DD
La-140	1.3E-08	8.7E-08	DD	4.2E-09	2.7E-08	DD	2.0E-09	1.3E-08	DD
Ce-141	5.1E-09	4.0E-08	DD	1.5E-09	1.2E-08	DD	7.1E-10	5.5E-09	DD
Ce-144	3.9E-08	3.1E-07	DD	1.1E-08	9.2E-08	DD	5.2E-09	4.2E-08	DD
Pr-143	8.7E-09	7.0E-08	DD	2.6E-09	2.1E-08	DD	1.2E-09	9.3E-09	DD
Pb-210	3.6E-06	3.8E-05	KH	1.9E-06	4.4E-05	KH	6.9E-07	2.3E-05	KH
Bi-210	9.7E-09	7.6E-08	DD	2.9E-09	2.3E-08	DD	1.3E-09	1.0E-08	DD
Po-210	8.8E-06	7.6E-05	Mi	2.6E-06	2.5E-05	Mi	1.2E-06	1.3E-05	Ni

Nuclide	Infant (1a)			Child (10a)			Adult		
	e_{ing} Sv/Bq	$h_{ing, Organ}$ Sv/Bq	**Organ**	e_{ing} Sv/Bq	$h_{ing, Organ}$ Sv/Bq	**Organ**	e_{ing} Sv/Bq	$h_{ing, Organ}$ Sv/Bq	**Organ**
Ra-224	6.6E-07	2.3E-05	KH	2.6E-07	1.1E-05	KH	6.5E-08	1.7E-06	KH
Ra-226	9.6E-07	2.9E-05	KH	8.0E-07	3.9E-05	KH	2.8E-07	1.2E-05	KH
Th-227	7.0E-08	8.0E-07	KH	2.3E-08	3.9E-07	KH	8.8E-09	8.8E-08	KH
Th-228	3.7E-07	8.4E-06	KH	1.4E-07	4.3E-06	KH	7.2E-08	2.5E-06	KH
Th-230	4.1E-07	1.3E-05	KH	2.4E-07	1.1E-05	KH	2.1E-07	1.2E-05	KH
Th-232	4.5E-07	1.3E-05	KH	2.9E-07	1.2E-05	KH	2.3E-07	1.2E-05	KH
Pa-231	1.3E-06	6.0E-05	KH	9.2E-07	4.6E-05	KH	7.1E-07	3.6E-05	KH
U-234	1.3E-07	1.8E-06	KH	7.4E-08	1.5E-06	KH	4.9E-08	7.8E-07	KH
U-235	1.3E-07	1.7E-06	KH	7.1E-08	1.4E-06	KH	4.7E-08	7.4E-07	KH
U-238	1.2E-07	1.6E-06	KH	6.8E-08	1.4E-06	KH	4.5E-08	7.1E-07	KH
Np-237	2.1E-07	5.0E-06	KH	1.1E-07	4.1E-06	KH	1.1E-07	5.4E-06	KH
Np-239	5.7E-09	4.4E-08	DD	1.7E-09	1.3E-08	DD	8.0E-10	6.0E-09	DD
Pu-238	4.0E-07	6.9E-06	KH	2.4E-07	5.9E-06	KH	2.3E-07	7.4E-06	KH
Pu-239	4.2E-07	7.6E-06	KH	2.7E-07	6.8E-06	KH	2.5E-07	8.2E-06	KH
Pu-240	4.2E-07	7.6E-06	KH	2.7E-07	6.8E-06	KH	2.5E-07	8.2E-06	KH
Pu-241	5.7E-09	1.2E-07	KH	5.1E-09	1.4E-07	KH	4.8E-09	1.6E-07	KH
Am-241	3.7E-07	8.3E-06	KH	2.2E-07	7.3E-06	KH	2.0E-07	9.0E-06	KH
Cm-242	7.6E-08	9.7E-07	KH	2.4E-08	3.5E-07	KH	1.2E-08	1.9E-07	KH
Cm-244	2.9E-07	5.8E-06	KH	1.4E-07	3.9E-06	KH	1.2E-07	4.9E-06	KH

e_{ing}: Committed effective dose; integration period: 50 years for adults, 70 years for children
Dose coefficients taken from: ICRP, 2012. Compendium of Dose Coefficients based on ICRP Publication 60. ICRP Publication 119. Ann. ICRP 41(Suppl.). Table F.1 (AMAD = 1µm)
Dose coefficients for other nuclides and for other age categories can be found in ICRP Publication 119.

$h_{ing, Organ}$: Committed dose in the most affected organ [WB: whole body, Go: gonads, BM: bone marrow (red), Co: colon, Lu: lung, St: stomach, Bl: bladder, Br: breast, Li: liver, Oe: oesophagus, Th: thyroid, Sk: skin, BS: bone surface, remainder (ET: extrathoracic airways, Ut: uterus, Ki: kidney, Sp: spleen)]
Dose coefficients taken from: ICRP Database of Dose Coefficients: Workers and Members of the Public; Ver. 3.0 – Free Educational CD Downloads (AMAD = 1µm)

[2] Organically bound tritium

Annex 6
(Art. 139 para. 2 and 194 para. 3)

Dose coefficients for cloudshine and groundshine

Nuclide	External exposure from cloudshine	External exposure from groundshine
	e_{imm} (mSv/h)/(Bq/m^3)	e_{sol} (mSv/h)/(Bq/m^2)
H-3	0.0E+00	0.0E+00
C-11	1.6E-07	3.6E-09
C-14	9.4E-12	4.6E-14
O-15	1.7E-07	3.9E-09
F-18	1.6E-07	3.4E-09
Na-22	3.7E-07	7.4E-09
Na-24	7.5E-07	1.3E-08
Sc-47	1.7E-08	3.6E-10
Cr-51	5.0E-09	1.1E-10
Mn-54	1.4E-07	2.8E-09
Fe-59	2.0E-07	4.0E-09
Co-57	1.8E-08	3.9E-10
Co-58	1.6E-07	3.3E-09
Co-60	4.3E-07	8.3E-09
Zn-65	9.8E-08	1.9E-09
Se-75	6.0E-08	1.3E-09
Br-82	4.4E-07	8.9E-09
Kr-79	4.0E-08	8.5E-10
Kr-81	8.8E-10	5.7E-12
Kr-83m	8.8E-12	1.2E-12
Kr-85	9.2E-10	3.8E-11
Kr-85m	2.5E-08	5.6E-10
Kr-87	1.4E-07	3.0E-09
Kr-88	3.5E-07	6.2E-09
Kr-88/Rb-88	4.7E-07	8.9E-09

Nuclide	External exposure from cloudshine	External exposure from groundshine
	e_{imm} (mSv/h)/(Bq/m^3)	e_{sol} (mSv/h)/(Bq/m^2)
Kr-89	3.4E-07	6.6E-09
Sr-89	1.6E-09	2.5E-10
Sr-90	3.5E-10	5.9E-12
Sr-90/Y-90	3.2E-09	4.0E-10
Y-91	2.2E-09	2.7E-10
Zr-95	1.2E-07	2.5E-09
Nb-95	1.3E-07	2.6E-09
Mo-99	2.5E-08	6.4E-10
Mo-99/Tc-99m	4.2E-08	1.0E-09
Tc-99m	1.9E-08	4.1E-10
Ru-103	8.0E-08	1.7E-09
Ru-106	0.0E+00	0.0E+00
Ru-106/Rh-106	3.9E-08	1.2E-09
Ag-110m	4.6E-07	9.3E-09
Sn-125	5.9E-08	1.4E-09
Sb-122	7.3E-08	1.8E-09
Sb-124	3.2E-07	6.2E-09
Sb-125	6.8E-08	1.5E-09
Sb-127	1.1E-07	2.4E-09
Te-125m	1.2E-09	9.6E-11
Te-127m	4.0E-10	3.1E-11
Te-129m	5.7E-09	2.1E-10
Te-131m	2.4E-07	4.9E-09
Te-132	3.4E-08	7.7E-10
Te-132/I-132	4.1E-07	8.6E-09

Nuclide	External exposure from cloudshine	External exposure from groundshine
	e_{imm} (mSv/h)/(Bq/m^3)	e_{sol} (mSv/h)/(Bq/m^2)
I-125	1.4E-09	1.1E-10
I-129	1.0E-09	7.2E-11
I-130	3.5E-07	7.4E-09
I-131	6.1E-08	1.3E-09
I-132	3.7E-07	7.8E-09
I-133	1.0E-07	2.2E-09
I-134	4.4E-07	9.0E-09
I-135	2.7E-07	5.3E-09
Xe-122	7.9E-09	2.2E-10
Xe-123	1.0E-07	2.2E-09
Xe-125	3.9E-08	8.9E-10
Xe-127	4.0E-08	9.2E-10
Xe-129m	3.4E-09	1.5E-10
Xe-131m	1.3E-09	5.9E-11
Xe-133	5.0E-09	1.5E-10
Xe-133m	4.6E-09	1.3E-10
Xe-135	4.0E-08	9.0E-10
Xe-135m	6.7E-08	1.5E-09
Xe-137	3.7E-08	1.3E-09
Xe-138	2.0E-07	3.9E-09
Cs-134	2.5E-07	5.3E-09
Cs-136	3.5E-07	7.2E-09
Cs-137	3.4E-10	1.1E-11
Cs-137/Ba-137m	9.2E-08	2.0E-09
Ba-140	2.9E-08	6.9E-10
Ba-140/La-140	4.3E-07	8.4E-09
La-140	4.0E-07	7.7E-09
Ce-141	1.1E-08	2.5E-10
Ce-144	2.6E-09	6.2E-11
Ce-144/Pr-144	1.2E-08	6.4E-10
Pr-143	7.0E-10	7.5E-11
Pb-210	1.7E-10	7.8E-12
Bi-210	9.3E-10	1.3E-10
Po-210	1.6E-12	3.3E-14
Ra-224	1.6E-09	3.5E-11
Ra-226	1.1E-09	2.4E-11
Th-227	1.9E-08	4.1E-10
Th-228	3.0E-10	7.8E-12
Th-230	5.5E-11	2.3E-12
Th-232	2.8E-11	1.6E-12
Pa-231	5.2E-09	1.2E-10
U-234	2.2E-11	2.1E-12
U-235	2.5E-08	5.4E-10
U-238	1.2E-11	1.4E-12
Np-237	3.1E-09	8.8E-11
Np-239	2.6E-08	5.8E-10
Pu-238	1.2E-11	2.2E-12
Pu-239	1.4E-11	1.1E-12
Pu-240	1.2E-11	2.0E-12
Pu-241	2.2E-13	5.1E-15
Am-241	2.4E-09	7.8E-11
Cm-242	1.4E-11	2.4E-12
Cm-244	1.4E-11	2.1E-12

e_{imm}: Dose coefficients for external exposure from immersion in a semi-infinite hemispherical cloud.

e_{sol}: Dose coefficients for external exposure from ground deposition over a wide area.

Zero values: Values less than 4.0E-19 are given as 0.0E+00.

Annex 7
(Art. 24 para. 1 and 2)

Immission limits

1 Immission limits for air (LI_{air}):

1.1 The immission limits for air are defined in such a way that permanent residence (8766 hours per year = *PR*) at a location with an airborne activity concentration equal to the immission limit for a specific nuclide would lead, based on inhalation and immersion, to an annual dose of 0.3 mSv for the critical person: infant (eb), ten-year old child (e10) or adult (Ad).

1.2

Nuclide	Immission limit for air [Bq/m^3]			
	Ad	e10	eb	**Minimum**
HTO	2.2E+03	2.3E+03	3.1E+03	2.2E+03
C-14 (org[67])	6.8E+01	6.7E+01	9.3E+01	6.7E+01
Na-22	2.7E+01	2.0E+01	1.9E+01	1.9E+01
Na-24	6.4E+01	5.1E+01	4.8E+01	4.8E+01
Mn-54	2.5E+01	2.1E+01	2.3E+01	2.1E+01
Co-60	3.9E+00	3.5E+00	4.3E+00	3.5E+00
Zn-65	2.4E+01	2.1E+01	2.2E+01	2.1E+01
Br-82	4.7E+01	3.8E+01	3.9E+01	3.8E+01
Sr-90/Y-90	1.1E+00	1.0E+00	1.3E+00	1.0E+00
Tc-99m	1.4E+03	1.2E+03	1.1E+03	1.1E+03
I-131 (el[68])	2.0E+00	1.1E+00	9.3E-01	9.3E-01
Cs-137/Ba-137m	8.5E+00	1.4E+01	2.7E+01	8.5E+00
Pu-239	7.9E-04	1.2E-03	1.9E-03	7.9E-04

1.3 The immission limits for air can be calculated for additional radionuclides using the following formula:

$$LI_{air}[\mathrm{Bq/m^3}] = \min\left(\frac{0.3\ \mathrm{mSv/a}}{DR_{eb}\cdot e_{inh,eb} + F_{abs}\cdot e_{imm}\cdot NH}; \frac{0.3\ \mathrm{mSv/a}}{DR_{e10}\cdot e_{inh,e10} + F_{abs}\cdot e_{imm}\cdot NH}; \frac{0.3\ \mathrm{mSv/a}}{DR_{ad}\cdot e_{inh,ad} + F_{abs}\cdot e_{imm}\cdot NH}\right)$$

where $e_{inh,eb}$, $e_{inh,e10}$ and $e_{inh,ad}$ [mSv/Bq] are the inhalation dose coefficients for infants, ten-year-old children and adults, and e_{imm} [(mSv/h)/(Bq/m^3)] is the immersion dose coefficient (non-age-dependent). The inhalation and immersion dose coefficients are taken from Annexes 5 and 6.

67 org = organic
68 el = elemental

For immersion, a shielding factor (F_{abs}) of 0.4 is assumed for time spent indoors.

For breathing rates for infants, ten-year-old children and adults (DR_{eb}, DR_{e10} and DR_{ad} [m^3/a]), the following values (ENSI-G14) were used:

a. DR_{eb} = 2022 [m^3/a]

b. DR_{e10} = 5688 [m^3/a]

c. DR_{ad}= 7584[m^3/a]

2 Immission limits for waters (LI_{eaux}):

2.1 The immission limits for publicly accessible waters are defined in such a way that the critical person entirely meeting their need for drinking water with water contaminated at a level corresponding to the immission limit would thus receive an annual ingestion dose of 0.3 mSv.

2.2

Nuclide	Immission limit for waters [Bq/l]			
	Ad	e10	eb	**Minimum**
HTO	2.6E+04	2.0E+04	2.5E+04	2.0E+04
C-14	8.0E+02	5.8E+02	7.5E+02	5.8E+02
Na-22	1.4E+02	8.4E+01	8.0E+01	8.0E+01
Na-24	1.1E+03	6.0E+02	5.2E+02	5.2E+02
Mn-54	6.5E+02	3.6E+02	3.9E+02	3.6E+02
Co-60	1.4E+02	4.2E+01	4.4E+01	4.2E+01
Zn-65	1.2E+02	7.2E+01	7.5E+01	7.2E+01
Sr-90/Y-90	1.6E+01	7.7E+00	1.6E+01	7.7E+00
Tc-99m	2.1E+04	1.1E+04	9.2E+03	9.2E+03
I-131 (el)	2.1E+01	8.9E+00	6.7E+00	6.7E+00
Cs-137/Ba-137m	3.6E+01	4.6E+01	1.0E+02	3.6E+01
Pu-239	1.8E+00	1.7E+00	2.9E+00	1.7E+00
Am-241	2.3E+00	2.1E+00	3.2E+00	2.1E+00

2.3 The immission limits for waters can be calculated for additional radionuclides using the following formula:

$$LI_{eaux}[\text{Bq/l}] = \min\left(\frac{0.3\ \text{mSv/a}}{e_{ing,eb} \cdot CoE_{eb}}; \frac{0.3\ \text{mSv/a}}{e_{ing,e10} \cdot CoE_{e10}}; \frac{0.3\ \text{mSv/a}}{e_{ing,ad} \cdot CoE_{ad}}\right)$$

where $e_{ing,eb}$, $e_{ing,e10}$ and $e_{ing,ad}$ [mSv/Bq] are the ingestion dose coefficients for infants, ten-year-old children and adults, and CoE_{eb}, CoE_{e10}, and CoE_{ad}

are the drinking water consumption in litres per year [l/a] for infants, ten-year-old children and adults.

For drinking water consumption, 650 l/a was assumed for adults and ten-year-old children, and 250 l/a for infants. The ingestion dose coefficients are taken from Annex 5.

3 In the case of nuclide mixtures, the summation rule applies for the immission limits for air and for waters:

Rule used to assess compliance with immission limits for air and for waters in the case of nuclide mixtures. Here, the various nuclides are weighted according to the hazard they pose. If the following inequalities are satisfied, then the mixtures are below the immission limits.

$$\frac{a_1}{LI_{\text{air}1}} + \frac{a_2}{LI_{\text{air}2}} + \ldots + \frac{a_n}{LI_{\text{air}n}} < 1$$

a_1, a_2, … a_n: airborne activity concentrations of nuclides 1, 2, …, n in Bq/m^3.

$LI_{\text{air}1}$, $LI_{\text{air }2}$, … $LI_{\text{air }n}$: immission limits for air for nuclides 1, 2, …, n in Bq/m^3.

$$\frac{a_1}{LI_{\text{eau}1}} + \frac{a_2}{LI_{\text{eau}2}} + \ldots + \frac{a_n}{LI_{\text{eau}n}} < 1$$

a_1, a_2, …a_n: airborne activity concentrations of nuclides 1, 2, ..., n in Bq/l.

$LI_{\text{eau}1}$, $LI_{\text{eau}2}$, … $LI_{\text{eau }n}$: immission limits for air for nuclides 1, 2, ..., n in Bq/l.

Annex 8[69]
(Art. 46 para. 4 let. b, 80 para. 5 and 85 para. 5)

Marking of controlled and supervised areas

Controlled and supervised areas must be marked as follows, depending on the radiation sources used:

1 Sealed radioactive sources:

a. the most radiotoxic nuclide or reference nuclide and its maximum activity, or the activity of and nuclide with the highest-energy gamma radiation;

b. the ambient dose rate in mSv per hour in the accessible area, if appropriate;

c. the hazard warning symbol.

2 Other radioactive material:

a. the most radiotoxic nuclide or reference nuclide and its maximum activity;

b. the classification of the working area (Type A, B or C) or the zone type;

c. the maximum degree of contamination caused by loose contamination on surfaces, expressed in Bq/cm^2 or as the number of guidance values for the nuclide concerned;

d. the maximum degree of contamination of indoor air in Bq/m^3;

e. the ambient dose rate in mSv per hour in the accessible area, if appropriate;

f. details of the protective clothing and protective measures required;

g. the hazard warning symbol.

3 Installations (e.g. X-ray equipment, accelerators):

a. the designation of the installation;

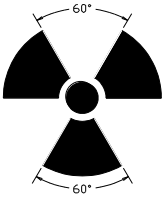
b. the type of radiation (e.g. electrons, X-rays, neutrons, where not apparent from the designation);

c. the ambient dose rate in mSv per hour in the accessible area, if appropriate;

d. the hazard warning symbol.

69 Revised by the correction of 5 June 2018 (AS **2018** 2273).

4 Hazard warning symbol:



Ratio of radii: 1 : 1,5 : 5

Annex 9
(Art. 96)

Activity values for the definition of high-activity sealed sources

For radionuclides not listed in the Table below, the activity value is the D value given in the IAEA publication «Dangerous quantities of radioactive material (D values)» (EPR-D-VALUES 2006)[70].

Radionuclide	Activity value (TBq)
Am-241	6×10^{-2}
Am-241/Be	6×10^{-2}
Cf-252	2×10^{-2}
Cm-244	5×10^{-2}
Co-60	3×10^{-2}
Cs-137	1×10^{-1}
Gd-153	1×10^{0}
Ir-192	8×10^{-2}
Pm-147	4×10^{1}
Pu-238	6×10^{-2}
Pu-239/Be[71]	6×10^{-2}
Ra-226	4×10^{-2}
Se-75	2×10^{-1}
Sr-90 (Y-90)	1×10^{0}
Tm-170	2×10^{1}
Yb-169	3×10^{-1}

70 The IAEA publications referred to in this O can be accessed free of charge on the IAEA website at www.iaea.org > Publications.
71 The activity of the alpha-emitting radionuclide is given.

Annex 10
(Art. 80 para. 2 let. b, 82 para. 1 and 2, 85 para. 2 let. b)

Zone types and area types

1. Depending on the degree of contamination which is present or to be expected, zones shall be classified into the following zone types:

Zone type	Surface contamination C_S	Airborne contamination C_A
0	$C_S < 1 \cdot CS$[72]	$C_A < 0.05 \cdot CA$[73]
I	$C_C < 1 \cdot CS$	$0.05 \cdot CA \leq C_A < 0.1 \cdot CA$
II	$1.CS \leq C_S < 10.CS$	$0.05.CA \leq C_A < 0.1.CA$
III	$10.CS \leq C_S < 100.CS$	$0.1.CA \leq C_A < 10.CA$
IV	$C_S \geq 100.CS$	$C_A \geq 10.CA$

If the degrees of airborne and surface contamination do not call for the same zone type, the more restrictive factor shall be decisive.

2. Within zones where ambient dose rates are elevated, for the planning and regulation of individual doses, the following areas must be designated with maximum permissible ambient dose rates:

Area type	Ambient dose rate D at accessible locations
V	$D < 0.01$ mSv/h
W	$0.01 < D < 0.1$ mSv/h
X	$0.1 < D < 1$ mSv/h
Y	$1 < D < 10$ mSv/h
Z	$D > 10$ mSv/h

72 Guidance value (Bq/cm^2) for surface contamination as specified in Annex 3 Column 12; averaged over 100 cm^2.
73 Guidance value (Bq/m^3) for chronic airborne activity as specified in Annex 3 Column 11.

Annex 11
(Art. 201)

Amendments to other legislation

The ordinances below are amended as follows:

…[74]

74 The amendments may be consulted under AS **2017** 4261..