RADIATION SAFETY DIRECTORATE

Pursuant to Article 22, paragraph 2 of the Law on Ionising Radiation Protection and Radiation Safety (Official Gazette of the Republic of Macedonia No. 48/02 and 135/07), the Director of the Radiation Safety Directorate hereby adopts a

RULEBOOK ON THE MANAGEMENT, COLLECTION, STORAGE, CONDITIONING, TRANSPORT AND DISPOSAL OF RADIOACTIVE WASTE

Article 1

This Rulebook shall prescribe the management, collection, storage, conditioning, transport and disposal of radioactive waste.

Article 2

Certain terms used in this Rulebook shall have the following meaning:

1. "Waste container" shall be a container wherein waste is emplaced in order to be managed, transported, stored and/or eventually disposed of, as well as an external barrier protecting the waste from external influences;

2. "Radioactive waste acceptance criteria" shall be the quantitative or qualitative criteria established by the Radiation Safety Directorate or the operator and approved by the Radiation Safety Directorate concerning the acceptance of radioactive waste on the part of the operator of the disposal or storage plant;

3. "Environmental impact assessment" shall be the assessment of the radiological and non-radiological impacts of a certain activity, whereby the total impact upon the environment is taken as an indicator, including radiological and other general measures affecting safety and the environment;

4. "Safety assessment" shall be the assessment of all aspects of a certain activity which are relevant for protection and safety, whereby the radiological impact and other general measures affecting safety are taken as indicators;

5. "Waste characterisation" shall be the determination of the physical, chemical and radiological characteristics of waste, for the purpose of establishing the need for further treatment and conditioning or the adequacy for further management, processing, storage or disposal thereof;

6. "Incineration" shall be a treatment of radioactive waste by incinerating it for the purpose of decreasing its volume and creating ashes as remnants of the incineration;

7. "Minimisation of radioactive waste" shall be a process of decreasing the quantity and activity of radioactive waste to a reasonably achievable low level, in all stages of the plant or activity design until the time it is put out of use, by decreasing the radioactive waste generation and by other means, such as recycling, reuse and treatment and by taking into consideration both the primary and the secondary radioactive waste;

8. "Radioactive waste package" shall be the conditioning product consisting of the radioactive waste, container/s and internal barriers prepared in accordance with the requirements on management, transport, storage and/or disposal;

9. "Radioactive waste additional package" shall be a secondary (or additional) external container for one or several packages for radioactive waste, which is used for management, transport, storage or disposal;

10. “Chemical precipitation” shall be a standard chemical method that may be used in the treatment of liquid waste, consisting of the removal of radionuclides from the liquid by forming an insoluble product of the chemical reaction or by their removal from the insoluble product obtained as a result of the chemical reaction in the liquid;

11. “Pre-disposal” shall be any phase of the management of radioactive waste before disposal, such as pre-treatment, treatment, conditioning, storage, transport and putting out of use;

12. “Pre-treatment” shall be any or all operations before the treatment of radioactive waste, such as collection, segregation, chemical adjustment, decontamination, etc.;

13. “Processing” shall be any operation leading to a change in the radioactive waste characteristics, including pre-treatment, treatment and conditioning;

14. “Segregation (isolation)” shall be the activity whereby radioactive waste or materials (radioactive and released) are separated or stored separately, in accordance with their radiological, chemical and/or physical characteristics, which will facilitate the management and/or processing thereof;

15. “Solidification” shall be the transformation of gaseous or liquid materials into solid radioactive waste, usually for the purpose of producing an easily manageable and physically stable material (such as drying, cementing, bitumenisation, etc.).

16. “Treatment” shall be the process of modifying the characteristics of radioactive waste in order to improve safety and/or cost-effectiveness, including volume decrease, removal of radionuclides from the radioactive waste and structure modification;

17. “Released waste” shall be radioactive waste released from control.

18. “Heat-generating radioactive waste” shall be such radioactive waste that generates heat in the process of its decay, thereby increasing its own and the surrounding temperature;

19. “High-activity radioactive waste” shall be radioactive waste with an activity concentration sufficient to generate a considerable amount of heat (thermal power higher than 2kW/m^3) in the process of radioactive decay or radioactive waste with high levels of long-lived radionuclides;

20. “Long-lived radioactive waste” shall be radioactive waste containing a considerable number of radionuclides with a half-life longer than 30 years;

21. “Low-activity and intermediate-activity radioactive waste” shall be either short-lived or long-lived radioactive waste whose radiological characteristics are between those of released and high-activity radioactive waste and whose thermal power is lower than or equal to 2 kW/m^3. This waste is subdivided into low-activity and intermediate-activity radioactive waste;

22. “Mixed waste” shall be radioactive waste containing both non-radioactive toxic and/or hazardous substances;

23. “Short-lived radioactive waste” shall be radioactive waste containing an inconsiderable number of radionuclides with a half-life longer than 30 years, as well as a concentration of long-lived radionuclides up to 4000 Bq/g in a single package of radionuclide waste and 400 Bq/g for the total mean concentration per package of radioactive waste;

24. “Very low-activity radioactive waste” shall be radioactive waste which need not necessarily fulfil the released waste criteria, which does not require a high level of maintenance and isolation and which is convenient for shallow surface disposal; and

25. “Conditioning” shall be the process whereby radioactive waste packages are produced, convenient for management, transport, storage and/or disposal. Conditioning includes

radioactive waste solidification and enclosing in containers and additional packages, where necessary.

Article 3

The management of radioactive waste and used radioactive sources shall include: radioactive waste generation, characterisation, collection, segregation, container marking, processing, pre-treatment, treatment, conditioning, package design, quality control of the conditioning process and of the packages produced, transport, storage of radioactive waste and used radioactive sources, recycling and reuse of materials, release of radioactive substances, release from control, as well as physical protection and safety, design, construction, operation and putting out of use of a radioactive waste storage plant.

A safety assessment and an environmental impact assessment shall be necessary for the management of radioactive waste referred to in paragraph 1 of this Article.

The assessments referred to in paragraph 2 of this Article shall include:

- analyses and a demonstration of the radiological and non-radiological safety under regular operating conditions and an assessment of the potential effects of a radiological emergency; and

- all the stages and aspects of the radioactive waste and used radioactive sources management process concerning occupationally exposed persons, the general public and the environment.

Article 4

Radioactive waste generation shall be reduced to the minimum by means of:

1. Planning of the design, construction, operation and reuse of the plant;

2. Adequate management of radioactive waste and reducing the production of secondary waste;

3. Reducing the volume and quantity of radioactive material requiring further processing by means of permitted release and application of the release levels, following any adequate processing and/or a sufficiently long storage period;

4. Minimising the radioactive waste activity by using minimal amounts of radioactive material;

5. Returning the used radioactive source to the manufacturer or supplier;

6. Implementing a detailed management system for all activities which might potentially create radioactive waste (management, processing, storage, etc.); and

7. Reusing and recycling materials, if possible.

Article 5

Radioactive waste generation shall be maintained to the minimum by means of:

1. Control of the collection, segregation, packaging and management of radioactive materials;

2. Establishing an appropriate segregation practice, including release of the materials;

3. Efficient collection and processing operations for gaseous and liquid radioactive waste;

4. Taking measures for preventing the contamination of materials, equipment and the surface of objects in order to reduce the need for decontamination;
5. Delimiting the take-over of packages and other unnecessary materials in the controlled

area; and

6. Planning and conducting periodic monitoring for the purpose of preventing the spreading of radioactive contamination.

Article 6

Regarding radioactive waste generation, records shall be kept and reports shall be submitted on the following:

1.The generated radioactive waste (date of generation, characteristics of the waste, etc.);

2.The stored radioactive waste (including identification, origin, location, physical and chemical characteristics, etc.);

3.The material released from control or released into the environment (including process-related data);

4. The wasted and/or used radioactive sources returned to the manufacturer or the supplier;

5. The radioactive waste and used radioactive sources transferred to the radioactive waste management plant; and

6. Non-compliances and measures taken.

Article 7

Radioactive waste shall be characterised according to the following:

1. Source origin;

2. Physical and chemical form;

3. Volume and/or mass;

4. Radiological characteristics (activity concentration, total activity, radionuclides contained and their relative representation);

5. Radioactive waste classification;

6. Radioactive waste categorisation;

7. All chemical, pathogenic or other hazards related to radioactive waste and concentrations of the hazardous material; and

8. Any special management which is of interest to the critical operation regime, the need for removing the heat generated from radioactive decay, etc.

Article 8

In management, radioactive waste shall be classified into:

1. Released waste;

2. Radioactive waste with radionuclides with a very short half-life – radioactive waste that may be stored over a limited period of time of a few years and be subsequently released from control; this class includes radionuclides used for research and medical purposes;

3. Very low activity radioactive waste;

4. Low activity radioactive waste – radioactive waste that is above release levels, but with limited amounts of long-lived radionuclides; such radioactive waste requires robust isolation and containment for periods of up to a few hundred years and is suitable for disposal in engineered near surface facilities; low activity radioactive waste may include short-lived radionuclides at higher levels of activity concentration and long-lived radionuclides, but only at relatively low levels of activity concentration;

5. Intermediate activity radioactive waste – radioactive waste that, because of its content, particularly of long-lived radionuclides, requires a greater degree of containment and isolation than that provided by near surface disposal; such waste needs only limited provision for heat dissipation during its storage and disposal; it may contain long-lived radionuclides, in particular alpha emitters, that will not decay to a level of activity concentration acceptable for near surface disposal; such radioactive waste requires disposal at greater depths, in the order of tens of metres to a few hundred metres; and
6. High activity radioactive waste – such radioactive waste requires disposal in stable geological formations several hundred metres below the surface.

Article 9

In management, radioactive waste shall be categorised on the basis of:

a) non-radioactive and radioactive materials;

b) the half-life of present radionuclides – short-lived radionuclides (e.g. with a half-life shorter than 100 days) or long-lived radionuclides (e.g. with a half-life longer than 30 years);

c) radionuclide activity and content;

d) the physical and chemical form:

• liquid:

- watery and

- organic;

• non-homogeneous (containing sediments or solid suspensions);

• solid:

- flammable/non-inflammable;

- compact/non-compact, and

- metal or non-metal;

e) fixed or non-fixed surface contamination;

f) used sealed radioactive sources, and

g) the characteristics of non-radiological hazards (e.g. chemical and biological toxicity). The categorisation referred to in paragraph 1 of this Article shall be performed by taking into consideration the radioactive waste acceptance criteria defined for each stage of the radioactive waste management process.

The acceptance criteria referred to in paragraph 2 of this Article shall be:

1. Stability of radioactive waste by taking into consideration the mechanical, chemical, structural, radiological and biological characteristics;

2. The maximum content of liquids;

3. Activity restriction (e.g. activity per package);

4. The degree of non-flammability, non-explosiveness and non-reactivity of radioactive waste, and

5. The possibility of generating toxic gases.

Article 10

During the stages of collecting radioactive waste, it shall be ensured that:

a) the solid radioactive waste containers are placed in a durable plastic bag that may be

closed (tied with a plastic adhesive tape, thermally closed);

b) sharp radioactive waste materials shall be collected and stored in special resistant containers (such as metal containers) and they shall be clearly labelled “sharp radioactive waste material”;

c) humid solid radioactive waste and liquid radioactive waste shall be collected in containers in accordance with the chemical and radiological characteristics, the volume of radioactive waste, the management and storage requirements (usually a double package is used);

d) used sealed radioactive sources shall be kept in their protective packages, and

e) containers shall be checked for presence of radioactive contamination and whether released contamination has been removed before their re-use.

Article 11

Radioactive waste shall be processed in a manner that provides operation safety under normal circumstances, taking measures for preventing the occurrence of incidents or catastrophes and taking steps for ameliorating any consequences that might arise.

Article 12

After segregation, radioactive waste shall be kept in containers that should be:

a) properly identified;

b) marked with an ionising radiation warning sign, if they contain radioactive waste;

c) durable;

d) compatible with the content of radioactive waste they contain; and

e) convenient for safe filling and emptying.

Article 13

The radioactive waste containers referred to in Article 12 of this Rulebook shall be identified and marked in a manner that the information required is available in all waste management stages.

The information referred to in paragraph 1 of this Article shall ensure the efficiency and safety of the following step in the process of managing radioactive waste and used radioactive sources and it shall contain:

a) an identification number;

b) radionuclides;

c) activity and date of activity (if it is known, measured or assessed);

d) origin (room, laboratory, etc., if relevant);

e) potential hazards (chemical, infective, etc.);

f) surface dose rate/measurement date; and

g) mass or volume.

Article 14

Radioactive waste shall be collected, characterised and isolated on the site where the radioactive waste is generated, in accordance with:

a) the established criteria and categorisation scheme;

b) the established manner and procedures of managing radioactive waste; and

c) the acceptance criteria for radioactive waste defined for the following step in the management process thereof.

Article 15

Radioactive waste shall:

a) be processed only after its precise characterisation; and

b) be treated according to methods selected on the basis of the waste characteristics and by taking into consideration the generation of secondary radioactive waste.

Article 16

Before treating radioactive waste, physical or chemical adjustment shall be effectuated, for the purpose of making radioactive waste less hazardous and adjusted for the forthcoming processing.

Article 17

The radioactive waste treatment shall include:

a) decreasing the volume of radioactive waste (by incinerating the flammable radioactive waste, swabbing solid radioactive waste and segmentation or dismantling the remaining components or equipment);

b) removal of radionuclides (by evaporation or ionic exchange for liquid radioactive waste and filtration for gaseous radioactive waste); and

c) change of the form or content (by chemical precipitation, flocculation/grouping and acidic digestion, chemical and thermal oxidation, etc.).

Article 18

Radioactive waste conditioning shall ensure its maximum homogeneity and stability, minimal free space in the container, low leaking rate and maximum container durability.

When selecting the conditioning process, the following shall be taken into consideration:

a) the usage of a metric material for improving safety;

b) the compatibility of the radioactive waste with the selected materials and processes; and

c) minimisation of the generation of secondary radioactive waste.

Article 19

The radioactive waste package design shall ensure the restriction of radionuclides under normal or exceptional circumstances that might appear during the management of radioactive waste.

For each package of conditioned radioactive waste, as referred to in paragraph 1 of this Article, an impervious label shall be provided, bearing the identification number and the relevant information; in addition, records shall be kept of this.

For each package, at least the following information shall be kept:

1. The origin of the radioactive waste;

2. The package identification number;

3. The type or details of the package design;

4. The package mass;

5. The external size and/or volume of the package.

6. The dose rate of the package surface and at a distance of 1m therefrom (transport index), and measurement date;

7. The results of the measurement of surface contamination;

8. The radionuclide content, activity and date of activity;

9. The content of fission material;

10. The physical nature; and

11. The presence of potential biological, chemical and other hazards.

Article 20

The quality control of the conditioning process and of the radioactive waste packages produced shall include:

1. Defining the quality standards applied to the radioactive waste packages;

2. Defining the quality indicators for the conditioning process and for the final packages, in a manner that they demonstrate that the packages comply with the specific requirements and the acceptance criteria;

3. Testing programme for verifying the package characteristics;

4. Record keeping; and

5. Providing technical support for radiological and non-radiological measurements and procedures.

Article 21

The transport of radioactive waste and used radioactive sources shall be performed in accordance with the relevant regulations on transporting radioactive material and the regulations on ionising radiation protection and radiation safety.

Article 22

The storage of radioactive waste and used radioactive sources shall be performed on the basis of previously established acceptance criteria.

Regarding the storage referred to in paragraph 1 of this Article, the availability of an appropriate storage installation, the containers and packages for radioactive waste that meet the criteria of this Rulebook and the regulations on ionising radiation protection and radiation safety shall be ensured.

Article 23

In cases where the radioactive waste and/or used radioactive sources to be stored do not meet the acceptance criteria, criteria that will compensate for the weaknesses shall be established, or the storage of such radioactive waste and/or used radioactive sources shall be rejected.

Article 24

Radioactive waste shall be stored in a manner that will enable its proper segregation, protection of the occupationally exposed persons, the general public and the environment, as well as its further removal, management, transport or disposal.

Article 25

The radioactive waste containing solely radionuclides with a very short half-life and with an activity concentration exceeding the release levels shall be stored in the facilities of the institution generating the radioactive waste by the time the activity concentration is reduced below the release level, thereby allowing for the released waste to be managed as conventional waste.

The radioactive waste and used radioactive sources that contain radionuclides with a half-life longer than 100 days shall be stored in a radioactive waste storage plant.

Article 26

Radioactive waste shall be stored in a manner that enables separating the treated and conditioned radioactive waste from the non-conditioned and non-radioactive waste and maintenance equipment.

Article 27

Used radioactive sources derived from imported radioactive sources shall be returned to the manufacturer or supplier.

Article 28

When managing used radioactive sources, the following shall be taken into consideration:
1. The used sealed radioactive sources with a high potential risk shall be stored separately;

2. For sources capable of leaking (such as radium), special radiological safety measures shall be taken in the course of management and storage, monitoring of surface and air contamination, storage in appropriately air-conditioned and equipped facilities, etc;

3. Used sealed radioactive sources shall be conditioned, unless the radionuclide half-life is sufficiently short to allow for their release from control;

4. The establishment of procedures that will ensure that the used sealed radioactive sources have not been subjected to swabbing, rending and incinerating; and

5. Taking measures preventing the loss of sources.

Article 29

As part of radioactive waste management, the possibility of material recycling and re-usage shall be taken into consideration.

Article 30

The release of radioactive substances from the radioactive waste storage plants into the

environment shall be performed in accordance with the regulations on ionising radiation protection and radiation safety.

Article 31

Radioactive material shall be released from control if the following requirements have been met:

a) the effective dose of exposure of an individual as a result of the released waste does not exceed 10 μSv annually;

b) the collective dose rate does not exceed 1 individual - Sv annually;

c) the equivalent dose on the skin does not exceed 50 mSv annually; and

d) the effective dose occasioned by unexpected occurrences that have resulted in higher exposure to radiation does not exceed 1 mSv annually.

Article 32

Radioactive material shall be released from control provided the release levels established in the Table given in the Appendix, which is a constituent part of this Rulebook, have not been exceeded.

Article 33

When releasing radioactive material from control, deliberate dilution of the material, which differs from dilution under normal operating circumstances, shall not be performed.

Article 34

When releasing radioactive material from control, all signs warning of ionising radiation hazard therefrom shall be removed, records of the material shall be kept and a report shall be submitted.

Article 35

When releasing radioactive material from control, the following measures shall be taken:

a) determining the waste activity concentration;

b) segregation of the waste intended for decay;

c) taking samples of the radioactive waste before release from control;

d) assessment of the doses of released radioactive material pertaining to an individual of the general public; and

e) keeping records and submitting reports to the Radiation Safety Directorate.

Article 36

The radioactive waste management plant shall be provided with physical protection against and security from unauthorised access of persons and unauthorised removal of radioactive materials.

Article 37

In the design, construction and operation of the radioactive waste management plant, the nuclear safety standards shall be taken into consideration.

Article 38

In the management of radioactive waste, a plan for putting the radioactive waste storage plant out of use shall be made, as well as a plan for the financial resources required for that purpose.

Article 39

On the day of entry into force of this Rulebook, the Rulebook on the collection, recording, processing, storage, final emplacement and release of radioactive waste materials into the environment (Official Gazette of SFRY No. 40/86) shall cease to apply.

Article 40

This Rulebook shall enter into force on the eighth day from the date of its publication in the Official Gazette of the Republic of Macedonia.

No. 01-1110/2
28 September 2010
Skopje

Director,
PhD **Nuzi Shahin**

Appendix

Table

Radionuclide	**Release levels [Bq/g]**
H-3	$8{,}6 \cdot 10^{2}$
Be-7	6,9
C-14	$6{,}3 \cdot 10^{1}$
F-18	$1{,}3 \cdot 10^{1}$
Na-22	$1{,}3\text{-}10^{-1}$
Na-24	$2{,}1 \cdot 10^{-1}$
Si-31	$1{,}2 \cdot 10^{2}$
P-32	$9{,}8 \cdot 10^{1}$
P-33	$2{,}3 \cdot 10^{2}$
S-35	$5{,}7 \cdot 10^{1}$
Cl-36	$1{,}6 \cdot 10^{1}$
Cl-38	$7{,}3 \cdot 10^{-1}$
K-40	1,5
K-42	4,0
K-43	$7{,}3 \cdot 10^{-1}$
Ca-45	$4{,}0 \cdot 10^{1}$
Ca-47	$3{,}2 \cdot 10^{-1}$
Sc-46	$1{,}5 \cdot 10^{1}$
Sc-47	5,2
Sc-48	$1{,}3 \cdot 10^{-1}$
V-48	$1{,}1 \cdot 10^{-1}$
Cr-51	$1{,}2 \cdot 10^{2}$
Mn-51	1,3
Mn-52	$1{,}0 \cdot 10^{-1}$
Mn-52m	$4{,}9 \cdot 10^{-1}$
Mn-53	$4{,}5 \cdot 10^{2}$
Mn-54	$3{,}8 \cdot 10^{-1}$
Mn-56	$6{,}6 \cdot 10^{-1}$
Fe-52	$4{,}5 \cdot 10^{-1}$

Radionuclide	**Release levels [Bq/g]**

Radionuclide	**Release levels [Bq/g]**

Fe-55	$4{,}7 \cdot 10^{1}$
Fe-59	$2{,}6 \cdot 10^{-1}$
Co-55	$4{,}2 \cdot 10^{-1}$
Co-56	$8{,}3 \cdot 10^{-2}$
Co-57	4,4
Co-58	$3{,}3 \cdot 10^{-1}$
Co-58m	$2{,}3 \cdot 10^{2}$
Co-60	$9{,}9 \cdot 10^{-2}$
Co-60m	$3{,}4 \cdot 10^{2}$
Co-61	$3{,}5 \cdot 10^{1}$
Co-62m	$4{,}1 \cdot 10^{-1}$
Ni-59	$2{,}9 \cdot 10^{2}$
Ni-63	$1{,}2 \cdot 10^{2}$
Ni-65	2,0
Cu-64	6,8
Zn-65	$5{,}2 \cdot 10^{-1}$
Zn-69	$1{,}6 \cdot 10^{2}$
Zn-69m	2,7
Ga-72	$3{,}6 \cdot 10^{-1}$
Ge-71	$1{,}0 \cdot 10^{4}$
As-73	$1{,}7 \cdot 10^{2}$
As-74	$4{,}5 \cdot 10^{-1}$
As-76	1,4
As-77	$6{,}7 \cdot 10^{1}$
Se-75	1,1
Br-82	$1{,}9 \cdot 10^{-1}$
Rb-86	3,3
Sr-85	$6{,}6 \cdot 10^{-1}$
Sr-85m	$1{,}1 \cdot 10^{1}$
Sr-87m	4,5
Sr-89	$2{,}8 \cdot 10^{1}$
Sr-90 +	1,1
Sr-91	1,7
Radionuclide	**Release levels [Bq/g]**
Ag-108m +	$1{,}4 \cdot 10^{-1}$
Ag-110m	$1{,}1 \cdot 10^{-1}$

Sr-92	$7{,}8 \cdot 10^{-1}$
Y-90	$1{,}4 \cdot 10^{2}$
Y-91	$2{,}5 \cdot 10^{1}$
Y-91m	2,4
Y-92	4,5
Y-93	$1{,}4 \cdot 10^{1}$
Zr-93 +	$6{,}0 \cdot 10^{1}$
Zr-95	$2{,}9 \cdot 10^{-1}$
Zr-97 +	$3{,}1 \cdot 10^{-1}$
Nb-93m	$1{,}1 \cdot 10^{2}$
Nb-94	$1.4 \cdot 10^{-1}$
Nb-95	$4{,}2 \cdot 10^{-1}$
Nb-97	1,8
Nb-98	$4{,}6 \cdot 10^{-1}$
Mo-90	1,8
Mo-93	$1.3 \cdot 10^{1}$
Mo-99	2,0
Mo-101	$7{,}4 \cdot 10^{-1}$
Tc-96	$1{,}5 \cdot 10^{-1}$
Tc-96m	$1{,}9 \cdot 10^{1}$
Tc-97	$2{,}0 \cdot 10^{2}$
Tc-97m	$7{,}5 \cdot 10^{1}$
Tc-99	$2{,}1 \cdot 10^{1}$
Tc-99m	$5{,}3 \cdot 10^{1}$
Ru-97	2,2
Ru-103	$7{,}1 \cdot 10^{-1}$
Ru-105	1,6
RU-106 +	2,5
Rh-103m	$1{,}0 \cdot 10^{4}$
Rh-105	7,7
Pd-103	$1 \cdot 10^{3}$
Pd-109	$8{,}5 \cdot 10^{1}$
Ag-105	$6{,}9 \cdot 10^{-1}$
Radionuclide	**Release levels [Bq/g]**
I-132	$5{,}2 \cdot 10^{-1}$
I-133	1,2

Ag-111	$1.5 \cdot 10^{1}$
Cd-109	$1,4 \cdot 10^{1}$
Cd-115	1,4
Cd-115m	$1,4 \cdot 10^{1}$
In-111	1,4
In-113m	5,6
In-114m	3,0
In-115m	9,9
Sn-113	1,4
Sn-125	1,1
Sb-122	$9,6 \cdot 10^{-1}$
Sb-124	$1,6 \cdot 10^{-1}$
Sb-125	$6,6 \cdot 10^{-1}$
Te-123m	3,5
Te-125m	$7,1 \cdot 10^{1}$
Te-127	$1,5 \cdot 10^{2}$
Te-127m	$1,3 \cdot 10^{1}$
Te-129	$2,5 \cdot 10^{1}$
Te-129m	5,2
Te-131	3,6
Te-131m	$3,6 \cdot 10^{-1}$
Te-132	$1,8 \cdot 10^{-1}$
Te-133	1,3
Te-133m	$5,1 \cdot 10^{-1}$
Te-134	$7,3 \cdot 10^{-1}$
I-123	$1,1 \cdot 10^{1}$
I-125	7,4
I-126	$7,7 \cdot 10^{-1}$
I-129	$4,5 \cdot 10^{-1}$
I-130	$5,7 \cdot 10^{-1}$
I-131	1,0
Radionuclide	**Release levels [Bq/g]**
Gd-159	$2,7 \cdot 10^{1}$
Tb-160	$3,0 \cdot 10^{-1}$
Dy-165	$7,3 \cdot 10^{1}$
Dy-166	$1,6 \cdot 10^{1}$

I-134	$4,4 \cdot 10^{-1}$
I-135	$6,9 \cdot 10^{-1}$
Cs-129	2,4
Cs-131	$1,0 \cdot 10^{3}$
Cs-132	$5,2 \cdot 10^{-1}$
Cs-134	$1,8 \cdot 10^{-1}$
Cs-134m	$3,3 \cdot 10^{2}$
Cs-135	$4,3 \cdot 10^{1}$
Cs-136	$1,5 \cdot 10^{-1}$
CS-137 +	$3,8 \cdot 10^{-1}$
Cs-138	$4,8 \cdot 10^{-1}$
Ba-131	$8,6 \cdot 10^{-1}$
Ba-140 +	$1,7 \cdot 10^{-1}$
La-140	$2,0 \cdot 10^{-1}$
Ce-139	3,4
Ce-141	7,0
Ce-143	2,4
Ce-144 +	3,8
Pr-142	$1,2 \cdot 10^{1}$
Pr-143	$1,5 \cdot 10^{2}$
Nd-147	3,3
Nd-149	4,6
Pm-147	$6,0 \cdot 10^{1}$
Pm-149	$4,4 \cdot 10^{1}$
Sm-151	$1,6 \cdot 10^{2}$
Sm-153	$2,2 \cdot 10^{1}$
Eu-152	$2,1 \cdot 10^{-1}$
Eu-152m	3,9
Eu-154	$1,9 \cdot 10^{-1}$
Eu-155	9,0
Gd-153	9,8
Radionuclide	**Release levels [Bq/g]**
Hg-197m	$1,2 \cdot 10^{1}$
Hg-203	1,8
Tl-200	$4,7 \cdot 10^{-1}$
Tl-201	$1,1 \cdot 10^{1}$

Ho-166	$2{,}6 \cdot 10^{1}$
Er-169	$2{,}0 \cdot 10^{2}$
Er-171	5,2
Tm-170	$2{,}4 \cdot 10^{1}$
Tm-171	$1{,}5 \cdot 10^{2}$
Yb-175	$1.1 \cdot 10^{1}$
Lu-177	$1{,}5 \cdot 10^{1}$
Hf-181	$6{,}8 \cdot 10^{-1}$
Ta-182	$2{,}5 \cdot 10^{-1}$
W-181	$3{,}5 \cdot 10^{1}$
W-185	$1{,}2 \cdot 10^{2}$
W-187	1,5
Re-186	$3{,}6 \cdot 10^{1}$
Re-188	$1{,}8 \cdot 10^{1}$
Os-185	$4{,}9 \cdot 10^{-1}$
Os-191	$1{,}0 \cdot 10^{1}$
Os-191m	$5{,}0 \cdot 10^{2}$
Os-193	$1{,}1 \cdot 10^{1}$
Ir-190	$1{,}2 \cdot 10^{-1}$
Ir-192	$4{,}4 \cdot 10^{-1}$
Ir-194	8,9
Pt-191	2,0
Pt-193m	$1{,}1 \cdot 10^{2}$
Pt-197	$6{,}9 \cdot 10^{1}$
Pt-197m	$3{,}4 \cdot 10^{1}$
Au-198	1,1
Au-199	6,9
Hg-197	$1{,}8\text{-}10^{1}$
Radionuclide	**Release levels [Bq/g]**
Th-232	$1{,}4 \cdot 10^{-2}$
Th-234	$1{,}9 \cdot 10^{1}$
Pa-230	$5{,}3 \cdot 10^{-1}$
Pa-231	$1{,}9 \cdot 10^{-2}$
Pa-233	2,0
U-230 +	$3{,}8 \cdot 10^{-1}$

Tl-202	$8{,}5 \cdot 10^{-1}$
Tl-204	$1{,}3 \cdot 10^{1}$
Pb-203	2,0
Pb-210 +	$8{,}6 \cdot 10^{-3}$
Pb-212 +	1,0
Bi-206	$1{,}1 \cdot 10^{-1}$
Bi-207	$1{,}5 \cdot 10^{-1}$
Bi-210	$1{,}9 \cdot 10^{1}$
Bi-212 +	$9{,}4 \cdot 10^{-1}$
Po-203	$6{,}9 \cdot 10^{-1}$
Po-205	$7{,}7 \cdot 10^{-1}$
Po-207	$8{,}7 \cdot 10^{-1}$
Po-210	$2{,}5 \cdot 10^{-2}$
At-211	$4{,}2 \cdot 10^{1}$
Ra-223 +	$8{,}1 \cdot 10^{-1}$
Ra-224 +	$3{,}2 \cdot 10^{-1}$
Ra-225	$6{,}3 \cdot 10^{-1}$
Ra-226 +	$8{,}0 \cdot 10^{-3}$
Ra-227	8,6
Ra-228 +	$1{,}7 \cdot 10^{-2}$
Ac-227	$2{,}4 \cdot 10^{-2}$
Ac-228	1,3
Th-226 +	$5{,}9 \cdot 10^{1}$
Th-227	$4{,}5 \cdot 10^{-1}$
Th-228 +	$1{,}1 \cdot 10^{-1}$
Th-229 +	$4{,}2\text{-}10^{-2}$
Th-230	$1{,}2\text{-}10^{-1}$
Th-231	$1{,}3\text{-}10^{2}$

Radionuclide	**Release levels [Bq/g]**
Pu-244	$1{,}5 \cdot 10^{-1}$
Am-241	$1{,}7 \cdot 10^{-1}$
Am-242	$1{,}3 \cdot 10^{2}$
Am-242m +	$1{,}2 \cdot 10^{-1}$
Am-243 +	$1{,}7 \cdot 10^{-1}$

U-231	$1.1 \cdot 10^{1}$
U-232 +	$5,5 \cdot 10^{-2}$
U-233	$6,2 \cdot 10^{-1}$
U-234	$6,7 \cdot 10^{-1}$
U-235 +	$7,1 \cdot 10^{-1}$
U-236	$7,3 \cdot 10^{-1}$
U-237	4,5
U-238 +	$6,9 \cdot 10^{-1}$
U-239	$1,0 \cdot 10^{2}$
U-240 +	4,5
Np-237 +	$3,1 \cdot 10^{-1}$
Np-239	3,8
Np-240	1,1
Pu-234	$1,0 \cdot 10^{2}$
Pu-235	$1,0 \cdot 10^{2}$
Pu-236	$3,1 \cdot 10^{-1}$
Pu-237	$1,4 \cdot 10^{1}$
Pu-238	$1,5 \cdot 10^{-1}$
Pu-239	$1,4 \cdot 10^{-1}$
Pu-240	$1,4 \cdot 10^{-1}$
Pu-241	3,4
Pu-242	$1,5 \cdot 10^{-1}$
Pu-243	$1,6 \cdot 10^{2}$
Cm-242	1,2
Cm-243	$2,3 \cdot 10^{-1}$
Cm-244	$2,7 \cdot 10^{-1}$
Cm-245	$1,5 \cdot 10^{-1}$
Cm-246	$1,7 \cdot 10^{-1}$
Cm-247	$1,8 \cdot 10^{-1}$
Cm-248	$4,9 \cdot 10^{-2}$
Bk-249	$2,2 \cdot 10^{1}$
Cf-246	$1,3 \cdot 10^{1}$
Cf-248	$6,8 \cdot 10^{-1}$
Cf-249	$1,0 \cdot 10^{-1}$
Cf-250	$1,9 \cdot 10^{-1}$
Cf-251	$1,0 \cdot 10^{-1}$
Cf-252	$2,2 \cdot 10^{-1}$
Cf-253	2,7
Cf-254	$1,6 \cdot 10^{-1}$
Es-253	2,2
Es-254	$3,7 \cdot 10^{-1}$
Es-254m	$8,8 \cdot 10^{-1}$
Fm-254	$6,0 \cdot 10^{1}$
Fm-255	$1,8 \cdot 10^{1}$

The release levels of the radionuclides marked with “+” apply also to their radioactive daughter nuclides.