15 Annex - Energy

85. RULEBOOK ON LIMITS OF RADIOACTIVE CONTAMINATION OF THE ENVIRONMENT AND ON THE MANNER OF PERFORMANCE OF DECONTAMINATION

RULEBOOK

ON LIMITS OF RADIOACTIVE CONTAMINATION OF THE ENVIRONMENT AND ON THE MANNER OF PERFORMANCE OF DECONTAMINATION

(Official Gazette of the Federal Republic of Yugoslavia 9/99 and Official Gazette of Serbia and Montenegro 1/2003 – Constitutional Charter)

I BASIC PROVISIONS

Article 1

This Rulebook shall lay down the limits of radioactive contamination of the environment and the manner of performance of decontamination.

Article 2

Individual terms used in this Rulebook have the following meaning:

1) radioactive contamination of the environment refers to presence of radionuclides in the environment above the limits laid down in this Rulebook;

2) decontamination of the environment refers to the process of complete removal of radionuclides from the environment or reduction of their presence below the limits laid down in this Rulebook;

3) decontamination factor refers to the ratio between the initial level and the final level of radioactive contamination of the environment, which indicates effectiveness of decontamination;

4) derived concentrations of radionuclides in the environment refer to limit values of contamination of the environment which have been derived from primary or secondary limits on the basis of the standardised models and whose application ensures that the prescribed limits are not exceeded.

II LIMITS OF RADIOACTIVE CONTAMINATION OF THE ENVIRONMENT

Article 3

Limits of radioactive contamination of air, potable water and human food, which is a consequence of the prescribed application of sources of ionising radiation, shall be defined by the limits of annual intake of radionuclides in a human organism through breathing in (inhalation - GGUinh) and nutrition (ingestion – GGUing), as well as by derived concentrations of radionuclides in the environment (DC).

Article 4

Limits of annual intake of radionuclides (n) through inhalation (GGUinh) for professionally exposed persons shall be calculated as follows:

$$GGU_{inh,n} = \frac{GDp}{e(g)_{n,inh}}$$

where

GDp- the limit of effective dose for professionally exposed persons, expressed as 1% of the prescribed limits of doses;

e(g)n,inh- the defined expected effective dose for professionally exposed persons per unit intake of radionuclides (n) through inhalation.

Article 5

Limits of annual intake of radionuclides (n) through ingestion (GGUing) for professionally exposed persons shall be calculated as follows:

$$GGU_{ing,n} = \frac{Gr}{e(g)_{n,ing}}$$

where

GDr- the limit of effective dose for professionally exposed persons, expressed as 1% of the prescribed limits of doses;

e(g)n, ing- the defined expected effective dose for professionally exposed persons per unit intake of radionuclides (n) through ingestion.

Article 6

Derived concentration of radionuclides in the air for professionally exposed persons shall be calculated as follows:

$$Ikv_{,n} = \frac{GGU\ inh_{,n}}{2400}$$

where

GGU inh,n- the limit of annual intake of radionuclides through inhalation for professionally exposed persons

2400 [m3] – the quantity of air inhaled by a professionally exposed person during 2000 hours of working time per year.

Article 7

With respect to inhalation of short-lived descendants of radon (222Rn) and thoron (220Rn), limits of radioactive contamination of air for professionally exposed persons shall be expressed as the limits of exposure to the total energy of the issued alpha particles, i.e. of monthly exposure to radon.

Limits of annual intake through inhalation of descendants of radon (222Rn) and of descendants of thoron (220Rn) for professionally exposed persons are laid down in Table 1 which accompanies this Rulebook and forms an integral part hereof.

Article 8

Limits of annual intake of each individual radionuclide (n) through inhalation (GGUinh) for the population shall be calculated as follows:

$$GGU_{inh,n} = \frac{GDs}{e(g)_{n,inh}}$$

where

GD s – the limit of effective dose for the population, expressed as 1% of the prescribed limits of doses;

e(g)n,inh- the expected effective doses per unit intake of radionuclides (n) through inhalation for the population in the age group (g).

The expected effective doses e(g)n,inh per unit intake of radionuclides (n) through inhalation for the population in the age group (g) are laid down in Table 2 which accompanies this Rulebook and forms an integral part hereof.

Article 9

Limits of annual intake of radionuclides (n) through ingestion (GGUing) for the population shall be calculated as follows:

$$GGU_{ing,n} = \frac{GDs}{e(g)_{n,ing}}$$

where

GDs- the limit of effective dose for the population, expressed as 1% of the prescribed limits of doses;

e(g) n,ing- the expected effective doses per unit intake of radionuclides (n) through ingestion for the population in the age group (g).

The expected effective doses e(g)n,ing unit intake of radionuclides (n) through ingestion for the population in the age group (g) are laid down in Table 3 which accompanies this Rulebook and forms an integral part hereof.

Article 10

The derived concentrations of radionuclides in potable water (IKv) for the population shall be calculated as follows:

$$IK_v = \frac{GGUv}{V}$$

where

GGUv – the limit of annual intake of radionuclides through ingestion for the population;

V [m3] - the average annual intake of potable water per capita (730 l).

Notwithstanding the provision of paragraph 1 hereof, the derived concentrations of natural radionuclides in natural mineral waters shall be calculated on the basis of 10% of the annual limit of exposure of the population.

The derived concentrations of individual radionuclides for potable water are laid down in Table 4 which accompanies this Rulebook and forms an integral part hereof.

Article 11

The derived concentration of radionuclides in food (IKx) for the population shall be calculated as follows:

$$IKx = \frac{GGUing}{M}$$

where

GGUing- the limit of annual intake of radionuclides through ingestion for the population,

M [kg] – the quantity of food [kg] ingested by an individual from the population in the course of one year.

Article 12

The derived concentration of radionuclides in the air for the population shall be calculated as follows:

$$IK_{v,s} = \frac{GGUinx,s}{7200}$$

where

GGU inx,s – the limit of annual intake through inhalation for the population;

7200 [m3] – the quantity of air inhaled by an inhabitant in the course of one year.

Article 13

If there is contamination of the environment with two or more known radionuclides, the limits of contamination of the environment shall be calculated as follows:

$$S\frac{GUn}{GGU\ n}\ 1$$

or

$$S\frac{Kn}{IKn}\ 1$$

where

GUn – the annual intake of a certain radionuclide (n) through inhalation or ingestion, which shall be estimated on the basis of the level of radioactive contamination of the environment and on the basis of internationally accepted models;

GGUn- the limit of annual intake of a certain radionuclide (n);

Kn – the concentration of a certain radionuclide (n) in the air, food or potable water;

IKn- the derived concentration of a certain radionuclide (n) in the air, food or potable water.

Article 14

If there is exposure to ionising radiation from two or more sources (including external exposure as well), the limit of radioactive contamination of the environment shall be calculated as follows:

$$\frac{GU\ inh}{GGUinh} + \frac{GU\ ing}{GGU\ ing} + \frac{D\ 5}{GGD}\ \ 1$$

where

GUinh- the annual intake of radionuclides through inhalation;

GGUinh- the limit of annual intake of radionuclides through inhalation;

GUing- the annual intake of radionuclides through water and food;

GGUing- the limit of annual intake of radionuclides through water and food;

Ds- the dose of external exposure of professionally exposed persons and the population;

GGD – the annual limit of exposure of professionally exposed persons and the population.

Article 15

Soil shall be considered contaminated if radionuclides whose activity could cause exposure of the population above the prescribed limits of doses, taking into consideration external exposure and the possibility of contamination of air, water and food, are found in the soil or on its surface.

Article 16

The limits of radioactive contamination of medicines shall be equal to the limits of contamination prescribed for potable water.

The provision of paragraph 1 hereof shall not apply to radio-pharmaceutical preparations.

Article 17

The limits of radioactive contamination of substances for maintenance of personal hygiene, care and enhancement of beauty of face and body shall be equal to the limits prescribed for potable water.

By way of exception, curative and cosmetic substances which are applied to the skin, whose origin is natural and based on natural raw materials from the ground, may have the contents of natural radionuclides at the level of average natural values.

Article 18

The limit of radioactive contamination of tobacco and tobacco products for the radionuclides that emit alpha radiation shall be 3,710-2Bq/g.

Article 19

The limits of radioactive contamination of water for watering of animals shall be equal to the limits prescribed for potable water.

The limits of radioactive contamination of livestock feedstuffs and raw materials for production of fodder mixtures shall be equal to the limits of radioactive contamination prescribed for food.

Article 20

The levels of radioactive contamination of food, medicines, auxiliary curative substances, items of general use and other imported goods may not be greater than the defined level of radioactive contamination of corresponding domestic products.

Article 21

The limits of radioactive contamination of building materials used in building construction for the interior shall be as follows:

for radium (226Ra)-2102 Bq/kg;

for thorium (232Th)-3102 Bq/kg;

for potassium (40K)-3103 Bq/kg;

for the sum of activities of all artificial radionuclides - 4103 Bq/kg.

The gamma index for the building materials referred to in paragraph 1 hereof shall be smaller than 1 and it shall be calculated as follows:

$$I = \frac{CRa}{200} + \frac{CTh}{300} + \frac{Ck}{3000} + \frac{Cv}{4000}$$

where

CRa- the concentration of radium (226Ra) in Bq/kg

CTh- the concentration of thorium (232Th) in Bq/kg

CK- the concentration of potassium (40K) in Bq/kg

Cv- the concentration of all radionuclides of artificial origin in Bq/kg.

Article 22

The limits of radioactive contamination of building materials used in building construction for the exterior shall be as follows:

for radium (226Ra)-4102 Bq/kg;

for thorium (232Th)-3102 Bq/kg;

for potassium (40K) -5103 Bq/kg;

for the sum of activities of all artificial radionuclides – 4103 Bq/kg.

The gamma index for the building materials referred to in paragraph 1 hereof may not be greater than 1 and it shall be calculated as follows:

$$I = \frac{CRa}{400} + \frac{CTh}{300} + \frac{Ck}{5000} + \frac{Cv}{4000}$$

where

CRa- the concentration of radium (226Ra) in Bq/kg

CTh- the concentration of thorium (232Th) in Bq/kg

CK- the concentration of potassium (40K) in Bq/kg

Cv- the concentration of all radionuclides of artificial origin in Bq/kg.

Article 23

The limits of radioactive contamination of building materials used for civil engineering construction as substructure for roads, playgrounds and other civil engineering construction facilities (beneath the covering layer), determined such as not to influence the increase in intensity of the absorbed dose of gamma radiation in the air, shall be as follows:

for radium (226Ra)-7102 Bq/kg;

for thorium (232Th)-5102 Bq/kg;

for potassium (40K)-8103 Bq/kg;

for the sum of activities of all artificial radionuclides - 2103 Bq/kg.

The gamma index for the building materials referred to in paragraph 1 hereof may not be greater than 1 and it shall be calculated as follows:

$$I = \frac{CRa}{700} + \frac{CTh}{500} + \frac{Ck}{8000} + \frac{Cv}{2000}$$

where

CRa- the concentration of radium (226Ra) in Bq/kg

CTh- the concentration of thorium (232Th) in Bq/kg

CK- the concentration of potassium (40K) in Bq/kg

Cv- the concentration of all radionuclides of artificial origin in Bq/kg.

Article 24

Industrial waste material may not be disposed of in the environment if the contents of natural radionuclides of such material are higher than the prescribed limits of radioactive contamination, namely:

for radium (226Ra) C Ra> 4103 Bq/kg;

for thorium (232Th) > 3103 Bq/kg;

for potassium (40K) > 5104 Bq/kg;

and for the sum of activities of all artificial radionuclides > 1104 Bq/kg.

The gamma index for the materials referred to in paragraph 1 hereof may not be greater than 1 and it shall be calculated as follows:

$$I = \frac{CRa}{4000} + \frac{CTh}{3000} + \frac{Ck}{50000} + \frac{Cv}{10000}$$

where

CRa- the concentration of radium (226Ra) in Bq/kg

CTh- the concentration of thorium (232Th) in Bq/kg

CK- the concentration of potassium (40K) in Bq/kg

Cv - the concentration of all radionuclides of artificial origin in Bq/kg.

Article 25

Radioactive contamination of surfaces in the environment, contamination of humans (skin and visible mucous membranes) and their clothes may not exceed the limits laid down in Table 5 which accompanies this Rulebook and forms an integral part hereof.

Article 26

The limits of radioactive contamination of fluid and gaseous radioactive effluents which may be discharged into the environment shall be separately defined for each site and facility where radioactive effluents are created, on the basis of the environmental impact assessment and on the basis of 1% of the annual limit of exposure of the population.

Article 27

In case of radioactive contamination due to a nuclear accident, limits of radioactive contamination provided by the International Atomic Energy Agency (IAEA) shall apply.

III THE MANNER OF EXECUTION OF DECONTAMINATION OF THE ENVIRONMENT

Article 28

If some part of the environment is contaminated, isolation of that part of the environment and discontinuation of use or circulation of contaminated items shall be carried out forthwith, i.e. other prescribed protection measures shall be implemented.

Following the performed isolation of the contaminated zone, type of contamination shall be established and measurement of its level carried out, as well as detection of the cause of contamination performed.

If it is established that the levels of contamination exceed the prescribed limits, decontamination and prevention of further dispersal of contamination i.e. removal of the cause of contamination shall be immediately started.

Article 29

The procedure of decontamination of the environment shall be carried out in such a manner as to do the following:

1) prevent dispersion of contamination into the environment;

2) protect the surface surrounding the contaminated area (by plastic foils, paper and alike);

3) carry out decontamination in the direction starting from the edges and moving towards the centre of the contaminated area, i.e. from the area with higher level of contamination towards the less contaminated zones;

4) occasionally perform the measurement of the level of contamination for the purpose of assessment of efficiency of the applied procedure of decontamination;

5) check the level of surface contamination of the face and objects prior to transfer to a non-contaminated area;

6) isolate all used solutions and accessories for decontamination until their level of contamination has been measured.

In cases of contamination of the environment by radionuclides with short half-life, the contaminated zones or objects shall be kept isolated until the contamination has dropped below the prescribed limits.

Article 30

Premises wherein open sourced of radiation were handled may not be used for other purposes until the opinion of an authorised legal entity stating that the said premises are not contaminated has been obtained.

Materials, devices, equipment and other objects shall be regarded as potentially contaminated if they were in the vicinity or if they were used in operations during which contamination might occur. Such objects may not be used for other purposes until a proof that they are not contaminated has been provided.

Article 31

Users of open sources of ionising radiations shall have their own laundries for contaminated clothes.

Contaminated clothes shall be collected in plastic bags or containers with lids, so as to prevent dispersion of contamination.

In case of contamination by radionuclides with short half-life (in nuclear medicine), clothes shall be disposed of until contamination has dropped to a negligible level, after which these clothes shall be washed.

Clothes that cannot be decontaminated to the level below the prescribed limits shall be treated and disposed of as radioactive waste material.

Article 32

Users of open sources of radiation shall obtain instructions on procedure in case of contamination by these sources from a legal entity authorised for performance of decontamination.

Article 33

Decontamination of humans (skin and visible mucous membranes) shall always be carried out when presence of radioactive substances is detected on them.

Article 34

Decontamination of humans and the environment shall be performed in accordance with the methodology provided by the International Atomic Energy Agency (IAEA).

IV FINAL PROVISIONS

Article 35

The Rulebook on maximum limits of radioactive contamination of human environment and on performance of decontamination (Official Gazette of the Socialist Federal Republic of Yugoslavia 8/87), the Rulebook on maximum allowed limits of presence of radionuclides in livestock feedstuffs, raw materials for production of fodder mixtures and water for watering of animals and on conditions for their marketing and use for nutrition of animals if the contents of radionuclides exceed the defined limits of activity (Official Gazette of the Socialist Federal Republic of Yugoslavia 16/92) and the Rulebook on conditions for marketing and use of potable water, foodstuffs and items of general use which contain radioactive substances at the level exceeding the defined limits of activity (Official Gazette of the Socialist Federal Republic of Yugoslavia 23/86) shall be repealed from the day of entry into force of this Rulebook.

Article 36

This Rulebook shall enter into force on the eighth day following that of its publication in the Official Gazette of the Federal Republic of Yugoslavia.

Table 1

DERIVED CONCENTRATIONS OF RADIONUCLIDES IN POTABLE WATER FOR CERTAIN MOST COMMON RADIONUCLIDES

Radionuclide	Activity (Bq/l)
total activity of alpha unstable radionuclides	0.1
total activity of beta unstable radionuclides	1
3H	780
14C	25
60Co	2
89Sr	3.7
90Sr	0.1
129I	0.1
131I	0.6
134Cs	0.7
137Cs	1.0
210Pb	0.01
224Ra	0.02
226Ra	0.2
228Ra	0.1
232Th	0.1
234Th	0.01
234U	0.4
238U	0.4
239Pu	0.03

Table 2

EXPECTED EFFECTIVE DOSE PER UNIT INTAKE e (g) THROUGH INGESTION (SvBq-1) FOR THE POPULATION

Radionuclide	Half-life	Age g 1year		f 1 for g 1 > year	e(g)				
		f1	e (g)		age 1-2 years	age 2-7 years	age 7-12 years	age 12-17 years	age > 17 years
1	2	3	4	5	6	7	8	9	10
HYDROGEN									
Treated water	12.3 years	1.000	6.4 10-11	1.000	4.8 10-11	3.1 10-11	2.3 10-11	1.8 10-11	1.8 10-11
Organically bound tritium	12.3 years	1.000	1.2 10-10	1.000	1.2 10-10	7.3 10-11	5.7 10-11	4.2 10-11	4.2 10-11
BERYLLIUM									
7Be	53.3 d	0.020	1.8 10-10	0.005	1.3 10-10	7.7 10-11	5.3 10-11	3.5 10-11	2.8 10-11
10Be	1.60 106 years	0.020	1.4 10-8	0.005	8.0 10-9	4.1 10-9	2.4 10-9	1.4 10-9	1.1 10-9
CARBON									
11C	0.340 h	1.000	2.6 10-10	1.000	1.5 10-10	7.3 10-11	4.3 10-11	3.0 10-11	2.4 10-11
14C	5.73 103 years	1.000	1.4 10-9	1.000	1.6 10-9	9.9 10-10	8.0 10-10	5.7 10-10	5.8 10-10
FLUORINE									

18F	1.83 h	1.000	5.2 10-10	1.000	3.0 10-10	1.5 10-10	9.1 10-11	6.2 10-11	4.9 10-11
SODIUM									
22Na	2.60 years	1.000	2.1 10-8	1.000	1.5 10-8	8.4 10-9	5.5 10-9	3.7 10-9	3.2 10-9
24Na	15.0 h	1.000	3.5 10-9	1.000	2.3 10-9	1.2 10-9	7.7 10-10	5.2 10-10	4.3 10-10
MAGNESIUM									
28Mg	20.9 h	1.000	1.2 10-8	0.500	1.4 10-8	7.4 10-9	4.5 10-9	2.7 10-9	2.2 10-9
ALUMINIUM									
26Al	7.16 105 years	0.020	3.4 10-8	0.010	2.1 10-8	1.1 10-8	7.1 10-9	4.3 10-9	3.5 10-9
SILICON									
31Si	2.62 h	0.020	1.9 10-9	0.010	1.0 10-9	5.1 10-10	3.0 10-10	1.8 10-10	1.6 10-10
32Si	4.50 102 years	0.020	7.3 10-9	0.010	4.1 10-9	2.0 10-9	1.2 10-9	7.0 10-10	5.6 10-10
PHOSPHORUS									
32P	14.3 d	1.000	3.1 10-8	0.800	1.9 10-8	9.4 10-9	5.3 10-9	3.1 10-9	2.4 10-9
33P	25.4 d	1.000	2.7 10-9	0.800	1.8 10-9	9.1 10-10	5.3 10-10	3.1 10-10	2.4 10-10
SULPHUR									

35S (non-organic)	87.4 d	1.000	1.3 10-9	1.000	8.7 10-10	4.4 10-10	2.7 10-10	1.6 10-10	1.3 10-10
35S (organic)	87.4 d	1.000	7.7 10-9	1.000	5.4 10-9	2.7 10-9	1.6 10-9	9.5 10-10	7.7 10-10
CHLORINE									
36Cl	3.01 105 years	1.000	9.8 10-9	1.000	6.3 10-9	3.2 10-9	1.9 10-9	1.2 10-9	9.3 10-10
38Cl	0.620 h	1.000	1.4 10-9	1.000	7.7 10-10	3.8 10-10	2.2 10-10	1.5 10-10	1.2 10-10
39Cl	0.927 h	1.000	9.7 10-10	1.000	5.5 10-10	2.7 10-10	1.6 10-10	1.1 10-10	8.5 10-10
POTASSIUM									
40K	1.28 109 years	1.000	6.2 10-8	1.000	4.2 10-8	2.1 10-8	1.3 10-8	7.6 10-9	6.2 10-9
42K	12.4 h	1.000	5.1 10-9	1.000	3.0 10-9	1.5 10-9	8.6 10-10	5.4 10-10	4.3 10-10
43K	22.6 h	1.000	2.3 10-9	1.000	1.4 10-9	7.6 10-10	4.7 10-10	3.0 10-10	2.5 10-10
44K	0.369 h	1.000	1.0 10-9	1.000	5.5 10-10	2.7 10-10	1.6 10-10	1.1 10-10	8.4 10-11
45K	0.333 h	1.000	6.2 10-10	1.000	3.5 10-10	1.7 10-10	9.9 10-11	6.8 10-11	5.4 10-11
CALCIUM(a									
41Ca	1.40 105 years	0.600	1.2 10-9	0.300	5.2 10-10	3.9 10-10	4.8 10-10	5.0 10-10	1.9 10-10
45Ca	163 d	0.600	1.1 10-8	0.300	4.9 10-9	2.6 10-9	1.8 10-9	1.3 10-9	7.1 10-10
47Ca	4.53 d	0.600	1.3 10-8	0.300	9.3 10-9	4.9 10-9	3.0 10-9	1.8 10-9	1.6 10-9
SCANDIUM									

43Sc	3.89 h	0.001	1.8 10-9	1.0 10-4	1.2 10-9	6.1 10-10	3.7 10-10	2.3 10-10	1.9 10-10
44Sc	3.93 h	0.001	3.5 10-9	1.0 10-4	2.2 10-9	1.2 10-9	7.1 10-10	4.4 10-10	3.5 10-10
44mSc	2.44 d	0.001	2.4 10-8	1.0 10-4	1.6 10-8	8.3 10-9	5.1 10-9	3.1 10-9	2.4 10-9
46Sc	83.8 d	0.001	1.1 10-8	1.0 10-4	7.9 10-9	4.4 10-9	2.9 10-9	1.8 10-9	1.5 10-9
47Sc	3.35 d	0.001	6.1 10-9	1.0 10-4	3.9 10-9	2.0 10-9	1.2 10-9	6.8 10-10	5.4 10-10
48Sc	1.82 d	0.001	1.3 10-8	1.0 10-4	9.3 10-9	5.1 10-9	3.3 10-9	2.1 10-9	1.7 10-9
49Sc	0.956 h	0.001	1.0 10-9	1.0 10-4	5.7 10-10	2.8 10-10	1.6 10-10	1.0 10-10	8.2 10-11
TITANIUM									
44Ti	47.3 years	0.020	5.5 10-8	0.010	3.1 10-8	1.7 10-8	1.1 10-8	6.9 10-9	5.8 10-9
45Ti	3.08 h	0.020	1.6 10-9	0.010	9.8 10-10	5.0 10-10	3.1 10-10	1.9 10-10	1.5 10-10
VANADIUM									
47V	0.543 h	0.020	7.3 10-10	0.010	4.1 10-10	2.0 10-10	1.2 10-10	8.0 10-11	6.3 10-11
48V	16.2 d	0.020	1.5 10-8	0.010	1.1 10-8	5.9 10-9	3.9 10-9	2.5 10-9	2.0 10-9
49V	330 d	0.020	2.2 10-10	0.010	1.4 10-10	6.9 10-11	4.0 10-11	2.3 10-11	1.8 10-11
CHROMIUM									
48Cr	23.0 h	0.200	1.4 10-9	0.100	9.9 10-10	5.7 10-10	3.8 10-10	2.5 10-10	2.0 10-10
		0.020	1.4 10-9	0.010	9.9 10-10	5.7 10-10	3.8 10-10	2.5 10-10	2.0 10-10

49Cr	0.702 h	0.200	6.8 10-10	0.100	3.9 10-10	2.0 10-10	1.1 10-10	7.7 10-11	6.1 10-11
		0.020	6.8 10-10	0.010	3.9 10-10	2.0 10-10	1.1 10-10	7.7 10-11	6.1 10-11
51Cr	27.7 d	0.200	3.5 10-10	0.100	2.3 10-10	1.2 10-10	7.8 10-11	4.8 10-11	3.8 10-11
		0.200	3.3 10-10	0.010	2.2 10-10	1.2 10-10	7.5 10-11	4.6 10-11	3.7 10-11
MANGANESE									
51Mn	0.770 h	0.200	1.1 10-9	0.100	6.1 10-10	3.0 10-10	1.8 10-10	1.2 10-10	9.3 10-11
52Mn	5.59 d	0.200	1.2 10-8	0.100	8.8 10-9	5.1 10-9	3.4 10-9	2.2 10-9	1.8 10-9
52mMn	0.352 h	0.200	7.8 10-10	0.100	4.4 10-10	2.2 10-10	1.3 10-10	8.8 10-11	6.9 10-11
53Mn	3.70 106 years	0.200	4.1 10-10	0.100	2.2 10-10	1.1 10-10	6.5 10-11	3.7 10-11	3.0 10-11
54Mn	312 d	0.200	5.4 10-9	0.100	3.1 10-9	1.9 10-9	1.3 10-9	8.7 10-10	7.1 10-10
56Mn	2.58 h	0.200	2.7 10-9	0.100	1.7 10-9	8.5 10-10	5.1 10-10	3.2 10-10	2.5 10-10
IRON(b									
52Fe	8.28 h	0.600	1.3 10-8	0.100	9.1 10-9	4.6 10-9	2.8 10-9	1.7 10-9	1.4 10-9
55Fe	2.70 years	0.600	7.6 10-9	0.100	2.4 10-9	1.7 10-9	1.1 10-9	7.7 10-10	3.3 10-10
59Fe	44.5 d	0.600	3.9 10-8	0.100	1.3 10-8	7.5 10-9	4.7 10-9	3.1 10-9	1.8 10-9
60Fe	1.00 105 years	0.600	7.9 10-7	0.100	2.7 10-7	2.7 10-7	2.5 10-7	2.3 10-7	1.1 10-7
COBALT(v									
55Co	17.5 h	0.600	6.0 10-9	0.100	5.5 10-9	2.9 10-9	1.8 10-9	1.1 10-9	1.0 10-9

56Co	78.7 d	0.600	2.5 10-8	0.100	1.5 10-8	8.8 10-9	5.8 10-9	3.8 10-9	2.5 10-9
57Co	271 d	0.600	2.9 10-9	0.100	1.6 10-9	8.9 10-10	5.8 10-10	3.7 10-10	2.1 10-10
58Co	70.8 d	0.600	7.3 10-9	0.100	4.4 10-9	2.6 10-9	1.7 10-9	1.1 10-9	7.4 10-10
58mCo	9.15 h	0.600	2.0 10-10	0.100	1.5 10-10	7.8 10-11	4.7 10-11	2.8 10-11	2.4 10-11
60Co	5.27 years	0.600	5.4 10-8	0.100	2.7 10-8	1.7 10-8	1.1 10-8	7.9 10-9	3.4 10-9
60mCo	0.174 h	0.600	2.2 10-11	0.100	1.2 10-11	5.7 10-12	3.2 10-12	2.2 10-12	1.7 10-12
61Co	1.65 h	0.600	8.2 10-10	0.100	5.1 10-10	2.5 10-10	1.4 10-10	9.2 10-11	7.4 10-11
62mCo	0.232 h	0.600	5.3 10-10	0.100	3.0 10-10	1.5 10-10	8.7 10-11	6.0 10-11	4.7 10-11
NICKEL									
56Ni	6.10 d	0.100	5.3 10-9	0.050	4.0 10-9	2.3 10-9	1.6 10-9	1.1 10-9	8.6 10-10
57Ni	1.50 d	0.100	6.8 10-9	0.050	4.9 10-9	2.7 10-9	1.7 10-9	1.1 10-9	8.7 10-10
59Ni	7.50 104 years	0.100	6.4 10-10	0.050	3.4 10-10	1.9 10-10	1.1 10-10	7.3 10-11	6.3 10-11
63Ni	96.0 years	0.100	1.6 10-9	0.050	8.4 10-10	4.6 10-10	2.8 10-10	1.8 10-10	1.5 10-10
65Ni	2.52 h	0.100	2.1 10-9	0.050	1.3 10-9	6.3 10-10	3.8 10-10	2.3 10-10	1.8 10-10
66Ni	2.27 d	0.100	3.3 10-8	0.050	2.2 10-8	1.1 10-8	6.6 10-9	3.7 10-9	3.0 10-9
COPPER									
60Cu	0.387 h	1.000	7.0 10-10	0.500	4.2 10-10	2.2 10-10	1.3 10-10	8.9 10-11	7.0 10-11
61Cu	3.41 h	1.000	7.1 10-10	0.500	7.5 10-10	3.9 10-10	2.3 10-10	1.5 10-10	1.2 10-10
64Cu	12.7 h	1.000	5.2 10-10	0.500	8.3 10-10	4.2 10-10	2.5 10-10	1.5 10-10	1.2 10-10

67Cu	2.58 d	1.000	2.1 10-9	0.500	2.4 10-9	1.2 10-9	7.2 10-10	4.2 10-10	3.4 10-10
ZINC									
62Zn	9.26 h	1.000	4.2 10-9	0.500	6.5 10-9	3.3 10-9	2.0 10-9	1.2 10-9	9.4 10-10
63Zn	0.635 h	1.000	8.7 10-10	0.500	5.2 10-10	2.6 10-10	1.5 10-10	1.0 10-10	7.9 10-11
65Zn	244 d	1.000	3.6 10-8	0.500	1.6 10-8	9.7 10-9	6.4 10-9	4.5 10-9	3.9 10-9
69Zn	0.950 h	1.000	3.5 10-10	0.500	2.2 10-10	1.1 10-10	6.0 10-11	3.9 10-11	3.1 10-11
69mZn	13.8 h	1.000	1.3 10-9	0.500	2.3 10-9	1.2 10-9	7.0 10-10	4.1 10-10	3.3 10-10
71mZn	3.92 h	1.000	1.4 10-9	0.500	1.5 10-9	7.8 10-10	4.8 10-10	3.0 10-10	2.4 10-10
72Zn	1.94 d	1.000	8.7 10-9	0.500	8.6 10-9	4.5 10-9	2.8 10-9	1.7 10-9	1.4 10-9
GALLIUM									
65Ga	0.253 h	0.010	4.3 10-10	0.001	2.4 10-10	1.2 10-10	6.9 10-11	4.7 10-11	3.7 10-11
66Ga	9.40 h	0.010	1.2 10-8	0.001	7.9 10-9	4.0 10-9	2.5 10-9	1.5 10-9	1.2 10-9
67Ga	3.26 d	0.010	1.8 10-9	0.001	1.2 10-9	6.4 10-10	4.0 10-10	2.4 10-10	1.9 10-10
68Ga	1.13 h	0.010	1.2 10-9	0.001	6.7 10-10	3.4 10-10	2.0 10-10	1.3 10-10	1.0 10-10
70Ga	0.353 h	0.010	3.9 10-10	0.001	2.2 10-10	1.0 10-10	5.9 10-11	4.0 10-11	3.1 10-11
72Ga	14.1 h	0.010	1.0 10-8	0.001	6.8 10-9	3.6 10-9	2.2 10-9	1.4 10-9	1.1 10-9
73Ga	4.91 h	0.010	3.0 10-9	0.001	1.9 10-9	3 10-10	5.5 10-10	3.3 10-10	2.6 10-10

GERMANIUM

66Ge	2.27 h	1.000	8.3 10-10	1.000	5.3 10-10	2.9 10-10	1.9 10-10	1.3 10-10	1.0 10-10
67Ge	0.312 h	1.000	7.7 10-10	1.000	4.2 10-10	2.1 10-10	1.2 10-10	8.2 10-11	6.5 10-11
68Ge	288 d	1.000	1.2 10-8	1.000	8.0 10-9	4.2 10-9	2.6 10-9	1.6 10-9	1.3 10-9
69Ge	1.63 d	1.000	2.0 10-9	1.000	1.3 10-9	7.1 10-10	4.6 10-10	3.0 10-10	2.4 10-10
71Ge	11.8 d	1.000	1.2 10-10	1.000	7.8 10-11	4.0 10-11	2.4 10-11	1.5 10-11	1.2 10-11
75Ge	1.38 h	1.000	5.5 10-10	1.000	3.1 10-10	1.5 10-10	8.7 10-11	5.9 10-11	4.6 10-11
77Ge	11.3 h	1.000	3.0 10-9	1.000	1.8 10-9	9.9 10-10	6.2 10-10	4.1 10-10	3.3 10-10
78Ge	1.45 h	1.000	1.2 10-9	1.000	7.0 10-10	3.6 10-10	2.2 10-10	1.5 10-10	1.2 10-10

ARSENIC

69As	0.253 h	1.000	6.6 10-10	0.500	3.7 10-10	1.8 10-10	1.1 10-10	7.2 10-11	5.7 10-11
70As	0.876 h	1.000	1.2 10-9	0.500	7.8 10-10	4.1 10-10	2.5 10-10	1.7 10-10	1.3 10-10
71As	2.70 d	1.000	2.8 10-9	0.500	2.8 10-9	1.5 10-9	9.3 10-10	5.7 10-10	4.6 10-10
72As	1.08 d	1.000	1.1 10-8	0.500	1.2 10-8	6.3 10-9	3.8 10-9	2.3 10-9	1.8 10-9
73As	80.3 d	1.000	2.6 10-9	0.500	1.9 10-9	9.3 10-10	5.6 10-10	3.2 10-10	2.6 10-10
74As	17.8 d	1.000	1.0 10-8	0.500	8.2 10-9	4.3 10-9	2.6 10-9	1.6 10-9	1.3 10-9
76As	1.10 d	1.000	1.0 10-8	0.500	1.1 10-8	5.8 10-9	3.4 10-9	2.0 10-9	1.6 10-9
77As	1.62 d	1.000	2.7 10-9	0.500	2.9 10-9	1.5 10-9	8.7 10-10	5.0 10-10	4.0 10-10
78As	1.51 h	1.000	2.0 10-9	0.500	1.4 10-9	7.0 10-10	4.1 10-10	2.7 10-10	2.1 10-10

SELENIUM

70Se	0.683 h	1.000	1.0 10-9	0.800	7.1 10-10	3.6 10-10	2.2 10-10	1.5 10-10	1.2 10-10
73Se	7.15 h	1.000	1.6 10-9	0.800	1.4 10-9	7.4 10-10	4.8 10-10	2.5 10-10	2.1 10-10
73mSe	0.650 h	1.000	2.6 10-10	0.800	1.8 10-10	9.5 10-11	5.9 10-11	3.5 10-11	2.8 10-11
75Se	120 d	1.000	2.0 10-8	0.800	1.3 10-8	8.3 10-9	6.0 10-9	3.1 10-9	2.6 10-9
79Se	6.50 104 g	1.000	4.1 10-8	0.800	2.8 10-8	1.9 10-8	1.4 10-8	4.1 10-9	2.9 10-9
81Se	0.308 h	1.000	3.4 10-10	0.800	1.9 10-10	9.0 10-11	5.1 10-11	3.4 10-11	2.7 10-11
81mSe	0.954 h	1.000	6.0 10-10	0.800	3.7 10-10	1.8 10-10	1.1 10-10	6.7 10-11	5.3 10-11
83Se	0.375 h	1.000	4.6 10-10	0.800	2.9 10-10	1.5 10-10	8.7 10-11	5.9 10-11	4.7 10-11
BROMINE									
74Br	0.422 h	1.000	9.0 10-10	1.000	5.2 10-10	2.6 10-10	1.5 10-10	1.1 10-10	8.4 10-11
74mBr	0.691 h	1.000	1.5 10-9	1.000	8.5 10-10	4.3 10-10	2.5 10-10	1.7 10-10	1.4 10-10
75Br	1.63 h	1.000	8.5 10-10	1.000	4.9 10-10	2.5 10-10	1.5 10-10	9.9 10-11	7.9 10-11
76Br	16.2 h	1.000	4.2 10-9	1.000	2.7 10-9	1.4 10-9	8.7 10-10	5.6 10-10	4.6 10-10
77Br	2.33 d	1.000	6.3 10-10	1.000	4.4 10-10	2.5 10-10	1.7 10-10	1.1 10-10	9.6 10-11
80Br	0.290 h	1.000	3.9 10-10	1.000	2.1 10-10	1.0 10-10	5.8 10-11	3.9 10-11	3.1 10-11
80mBr	4.42 h	1.000	1.4 10-9	1.000	8.0 10-10	3.9 10-10	2.3 10-10	1.4 10-10	1.1 10-10
82Br	1.47 d	1.000	3.7 10-9	1.000	2.6 10-9	1.5 10-9	9.5 10-10	6.4 10-10	5.4 10-10
83Br	2.39 h	1.000	5.3 10-10	1.000	3.0 10-10	1.4 10-10	8.3 10-11	5.5 10-11	4.3 10-11
84Br	0.530 h	1.000	1.0 10-9	1.000	5.8 10-10	2.8 10-10	1.6 10-10	1.1 10-10	8.8 10-11

RUBIDIUM

79Rb	0.382 h	1.000	5.7 10-10	1.000	3.2 10-10	1.6 10-10	9.2 10-11	6.3 10-11	5.0 10-11
81Rb	4.58 h	1.000	5.4 10-10	1.000	3.2 10-10	1.6 10-10	1.0 10-10	6.7 10-11	5.4 10-11
81mRb	0.533 h	1.000	1.1 10-10	1.000	6.2 10-11	3.1 10-11	1.8 10-11	1.2 10-11	9.7 10-12
82mRb	6.20 h	1.000	8.7 10-10	1.000	5.9 10-10	3.4 10-10	2.2 10-10	1.5 10-10	1.3 10-10
83Rb	86.2 d	1.000	1.1 10-8	1.000	8.4 10-9	4.9 10-9	3.2 10-9	2.2 10-9	1.9 10-9
84Rb	32.8 d	1.000	2.0 10-8	1.000	1.4 10-8	7.9 10-9	5.0 10-9	3.3 10-9	2.8 10-9
86Rb	18.7 d	1.000	3.1 10-8	1.000	2.0 10-8	9.9 10-9	5.9 10-9	3.5 10-9	2.8 10-9
87Rb	4.70 1010 god	1.000	1.5 10-8	1.000	1.0 10-8	5.2 10-9	3.1 10-9	1.8 10-9	1.5 10-9
88Rb	0.297 h	1.000	1.1 10-9	1.000	6.2 10-10	3.0 10-10	1.7 10-10	1.2 10-10	9.0 10-11
89Rb	0.253 h	1.000	5.4 10-10	1.000	3.0 10-10	1.5 10-10	8.6 10-11	5.9 10-11	4.7 10-11

STRONTIUM(g

80Sr	1.67 h	0.600	3.7 10-9	0.300	2.3 10-9	1.1 10-9	6.5 10-10	4.2 10-10	3.4 10-10
81Sr	0.425 h	0.600	8.4 10-10	0.300	4.9 10-10	2.4 10-10	1.4 10-10	9.6 10-11	7.7 10-11
82Sr	25.0 d	0.600	7.2 10-8	0.300	4.1 10-8	2.1 10-8	1.3 10-8	8.7 10-9	6.1 10-9
83Sr	1.35 d	0.600	3.4 10-9	0.300	2.7 10-9	1.4 10-9	9.1 10-10	5.7 10-10	4.9 10-10
85Sr	64.8 d	0.600	7.7 10-9	0.300	3.1 10-9	1.7 10-9	1.5 10-9	1.3 10-9	5.6 10-10
85mSr	1.16 h	0.600	4.5 10-11	0.300	3.0 10-11	1.7 10-11	1.1 10-11	7.8 10-12	6.1 10-12
87mSr	2.80 h	0.600	2.4 10-10	0.300	1.7 10-10	9.0 10-11	5.6 10-11	3.6 10-11	3.0 10-11
89Sr	50.5 d	0.600	3.6 10-8	0.300	1.8 10-8	8.9 10-9	5.8 10-9	4.0 10-9	2.6 10-9

90Sr	29.1 god	0.600	2.3 10-7	0.300	7.3 10-8	4.7 10-8	6.0 10-8	8.0 10-8	2.8 10-8
91Sr	9.50 h	0.600	5.2 10-9	0.300	4.0 10-9	2.1 10-9	1.2 10-9	7.4 10-10	6.5 10-10
92Sr	2.71 h	0.600	3.4 10-9	0.300	2.7 10-9	1.4 10-9	8.2 10-10	4.8 10-10	4.3 10-10
IYTTRIUM									
86Y	14.7 h	0.001	7.6 10-9	1.0 10-4	5.2 10-9	2.9 10-9	1.9 10-9	1.2 10-9	9.6 10-10
86mY	0.800 h	0.001	4.5 10-10	1.0 10-4	3.1 10-10	1.7 10-10	1.1 10-10	7.1 10-11	5.6 10-11
87Y	3.35 d	0.001	4.6 10-9	1.0 10-4	3.2 10-9	1.8 10-9	1.1 10-9	7.0 10-10	5.5 10-10
88Y	107 d	0.001	8.1 10-9	1.0 10-4	6.0 10-9	3.5 10-9	2.4 10-9	1.6 10-9	1.3 10-9
90Y	2.67 d	0.001	3.1 10-8	1.0 10-4	2.0 10-8	1.0 10-8	5.9 10-9	3.3 10-9	2.7 10-9
90mY	3.19 h	0.001	1.8 10-9	1.0 10-4	1.2 10-9	6.1 10-10	3.7 10-10	2.2 10-10	1.7 10-10
91Y	58.5 d	0.001	2.8 10-8	1.0 10-4	1.8 10-8	8.8 10-9	5.2 10-9	2.9 10-9	2.4 10-9
91mY	0.828 h	0.001	9.2 10-11	1.0 10-4	6.0 10-11	3.3 10-11	2.1 10-11	1.4 10-11	1.1 10-11
92Y	3.54 h	0.001	5.9 10-9	1.0 10-4	3.6 10-9	1.8 10-9	1.0 10-9	6.2 10-10	4.9 10-10
93Y	10.1 h	0.001	1.4 10-8	1.0 10-4	8.5 10-9	4.3 10-9	2.5 10-9	1.4 10-9	1.2 10-9
94Y	0.318 h	0.001	9.9 10-10	1.0 10-4	5.5 10-10	2.7 10-10	1.5 10-10	1.0 10-10	8.1 10-11
95Y	0.178 h	0.001	5.7 10-10	1.0 10-4	3.1 10-10	1.5 10-10	8.7 10-11	5.9 10-11	4.6 10-11
ZIRCONIUM									
86Zr	16.5 h	0.020	6.9 10-9	0.010	4.8 10-9	2.7 10-9	1.7 10-9	1.1 10-9	8.6 10-10
88Zr	83.4 d	0.020	2.8 10-9	0.010	2.0 10-9	1.2 10-9	8.0 10-10	5.4 10-10	4.5 10-10

89Zr	3.27 d	0.020	6.5 10-9	0.010	4.5 10-9	2.5 10-9	1.6 10-9	9.9 10-10	7.9 10-10
93Zr	1.53 106 years	0.020	1.2 10-9	0.010	7.6 10-10	5.1 10-10	5.8 10-10	8.6 10-10	1.1 10-9
95Zr	64.0 d	0.020	8.5 10-9	0.010	5.6 10-9	3.0 10-9	1.9 10-9	1.2 10-9	9.5 10-10
97Zr	16.9 h	0.020	2.2 10-8	0.010	1.4 10-8	7.3 10-9	4.4 10-9	2.6 10-9	2.1 10-9
NIOBIUM									
88Nb	0.238 h	0.020	6.7 10-10	0.010	3.8 10-10	1.9 10-10	1.1 10-10	7.9 10-11	6.3 10-11
89Nb	2.03 h	0.020	3.0 10-9	0.010	2.0 10-9	1.0 10-9	6.0 10-10	3.4 10-10	2.7 10-10
89Nb	1.10 h	0.020	1.5 10-9	0.010	8.7 10-10	4.4 10-10	2.7 10-10	1.8 10-10	1.4 10-10
90Nb	14.6 h	0.020	1.1 10-8	0.010	7.2 10-9	3.9 10-9	2.5 10-9	1.6 10-9	1.2 10-9
93mNb	13.6 years	0.020	1.5 10-9	0.010	9.1 10-10	4.6 10-10	2.7 10-10	1.5 10-10	1.2 10-10
94Nb	2.03 104 years	0.020	1.5 10-8	0.010	9.7 10-9	5.3 10-9	3.4 10-9	2.1 10-9	1.7 10-9
95Nb	35.1 d	0.020	4.6 10-9	0.010	3.2 10-9	1.8 10-9	1.1 10-9	7.4 10-10	5.8 10-10
95mNb	3.61 d	0.020	6.4 10-9	0.010	4.1 10-9	2.1 10-9	1.2 10-9	7.1 10-10	5.6 10-10
96Nb	23.3 h	0.020	9.2 10-9	0.010	6.3 10-9	3.4 10-9	2.2 10-9	1.4 10-9	1.1 10-9
97Nb	1.20 h	0.020	7.7 10-10	0.010	4.5 10-10	2.3 10-10	1.3 10-10	8.7 10-11	6.8 10-11
98Nb	0.858 h	0.020	1.2 10-9	0.010	7.1 10-10	3.6 10-10	2.2 10-10	1.4 10-10	1.1 10-10
MOLYBDENUM									
90Mo	5.67 h	1.000	1.7 10-9	1.000	1.2 10-9	6.3 10-10	4.0 10-10	2.7 10-10	2.2 10-10
93Mo	3.50 103 years	1.000	7.9 10-9	1.000	6.9 10-9	5.0 10-9	4.0 10-9	3.4 10-9	3.1 10-9

93mMo	6.85 h	1.000	8.0 10-10	1.000	5.4 10-10	3.1 10-10	2.0 10-10	1.4 10-10	1.1 10-10
99Mo	2.75 d	1.000	5.5 10-9	1.000	3.5 10-9	1.8 10-9	1.1 10-9	7.6 10-10	6.0 10-10
101Mo	0.244 h	1.000	4.8 10-10	1.000	2.7 10-10	1.3 10-10	7.6 10-11	5.2 10-11	4.1 10-11

TECHNETIUM

93Tc	2.75 h	1.000	2.7 10-10	0.500	2.5 10-10	1.5 10-10	9.8 10-11	6.8 10-11	5.5 10-11
93mTc	0.725 h	1.000	2.0 10-10	0.500	1.3 10-10	7.3 10-11	4.6 10-11	3.2 10-11	2.5 10-11
94Tc	4.88 h	1.000	1.2 10-9	0.500	1.0 10-9	5.8 10-10	3.7 10-10	2.5 10-10	2.0 10-10
94mTc	0.867 h	1.000	1.3 10-9	0.500	6.5 10-10	3.3 10-10	1.9 10-10	1.3 10-10	1.0 10-10
95Tc	20.0 h	1.000	9.9 10-10	0.500	8.7 10-10	5.0 10-10	3.3 10-10	2.3 10-10	1.8 10-10
95mTc	61.0 d	1.000	4.7 10-9	0.500	2.8 10-9	1.6 10-9	1.0 10-9	7.0 10-10	5.6 10-10
96Tc	4.28 d	1.000	6.7 10-9	0.500	5.1 10-9	3.0 10-9	2.0 10-9	1.4 10-9	1.1 10-9
96mTc	0.858 h	1.000	1.0 10-10	0.500	6.5 10-11	3.6 10-11	2.3 10-11	1.6 10-11	1.2 10-11
97Tc	2.60 106 years	1.000	9.9 10-10	0.500	4.9 10-10	2.4 10-10	1.4 10-10	8.8 10-11	6.8 10-11
97mTc	87.0 d	1.000	8.7 10-9	0.500	4.1 10-9	2.0 10-9	1.1 10-9	7.0 10-10	5.5 10-10
98Tc	4.20 106 years	1.000	2.3 10-8	0.500	1.2 10-8	6.1 10-9	3.7 10-9	2.5 10-9	2.0 10-9
99Tc	2.13 105 years	1.000	1.0 10-8	0.500	4.8 10-9	2.3 10-9	1.3 10-9	8.2 10-10	6.4 10-10
99mTc	6.02 h	1.000	2.0 10-10	0.500	1.3 10-10	7.2 10-11	4.3 10-11	2.8 10-11	2.2 10-11
101Tc	0.237 h	1.000	2.4 10-10	0.500	1.3 10-10	6.1 10-11	3.5 10-11	2.4 10-11	1.9 10-11
104Tc	0.303 h	1.000	1.0 10-9	0.500	5.3 10-10	2.6 10-10	1.5 10-10	1.0 10-10	8.0 10-11