

Pursuant to Article 16(1) of the Law on Radiation and Nuclear Safety in Bosnia and Herzegovina ("Official Gazette of BiH" 88/07) and Article 61(2) of the Law on Administration ("Official Gazette of BiH" 32/02 and 102/09), the director of the State Regulatory Agency for Radiation and Nuclear Safety issues:

**REGULATION**  
**on the radiation protection in occupational exposure and public exposure**

**PART ONE – GENERAL PROVISIONS**

Article 1  
**(Subject)**

- (1) This regulation shall govern the principles of radiation protection of exposed workers and the population in ordinary situations, radiological and nuclear emergencies; principles of the radiation protection system; dose limits for exposed workers, apprentices, high-school and university students in training, and the population; the estimation model for effective dose; requirements for individual monitoring and monitoring of the workplace; responsibilities of the radiation protection experts; actions in the event of significant increase of exposure from natural sources and during interventions in radiological, nuclear emergencies and lasting exposures, as well as other matters important for occupational exposure and public exposure.
- (2) This regulation shall apply to all practices involving risk from ionizing radiation arising from an artificial or a natural source of ionizing radiation (hereinafter: source), when natural radionuclides are or have been processed in view of their radioactive, fissile or fertile properties, which implies:
  - a) production, processing, handling, use, possession, storage, transport, import, export, relocation, and disposal of radioactive substances,
  - b) the operation of any electrical equipment producing ionizing radiation and containing components operating at a potential difference of more than 5 kV,
  - c) any other practice as defined by the State Regulatory Agency for Radiation and Nuclear Safety (hereinafter: Agency).
- (3) This regulation shall apply to work activities that imply the presence of natural sources and lead to significant increase of exposure of exposed workers or the population, which cannot be disregarded from the radiation protection point of view.

Article 2  
**(Objective)**

The objective of this regulation is to establish standards and criteria for the radiation protection of exposed workers and the population.

Article 3  
**(Definitions)**

The terms and expressions, as used in this regulation, mean:

- a) *Action level*: The level of dose rate or activity concentration above which remedial or protective actions shall be carried out.
- b) *Activity (A)*: The activity  $A$  of an amount of a radionuclide in a particular energy state at a given time is the quotient of  $dN$  by  $dt$ , where  $dN$  is the expectation value of the number of spontaneous nuclear transitions from that energy state in the time interval  $dt$ :

$$A = \frac{dN}{dt}$$

- c) *Absorbed dose (D)*: The energy absorbed per unit mass

$$D = \frac{d\bar{\epsilon}}{dm}$$

where  $d\bar{\epsilon}$  is the mean energy imparted by ionizing radiation to the mass of the matter  $dm$  in the final volume  $V$ . In this regulation the absorbed dose means the dose averaged over a tissue or an organ.

- d) *Becquerel (Bq)*: The unit of activity. 1 Bq is equal to one transition per second.

$$1 \text{ Bq} = 1 \text{ s}^{-1}$$

- e) *Lasting exposure*: The exposure resulting from residual effects of radiological emergencies or the application of a practice or an activity in the past.
- f) *Effective dose (E)*: The sum of equivalent doses in all body tissues and organs as a result of internal and external exposures,  $H_T$ , each multiplied by the appropriate tissue or organ weighting factor  $w_T$  of a tissue or an organ  $T$ . It is determined by the formula:

$$E = \sum_T w_T H_T = \sum_T w_T \sum_R w_R D_{T,R}$$

where  $D_{T,R}$  is the absorbed dose average over tissue or organ  $T$ , due to radiation  $R$ , while  $w_R$  is the radiation weighting factor.

Appropriate values for  $w_T$  and  $w_R$  are given in Annex 1.

The unit for effective dose is the sievert (Sv).

- g) *Radiation protection expert*: A person with relevant knowledge and training to conduct physical, technical and radiochemical tests needed for dose estimations, and to provide

expertise in order to ensure effective individual protection, proper use and operation of protective equipment and measuring instruments, and who is responsible for technical aspects of radiation protection for exposed workers and the population. Qualifications of the radiation protection expert to perform the above duties shall be recognized by the Agency.

- h) *Accidental exposure*: An exposure of individuals as a result of an accident, excluding emergency exposure.
- i) *Exposure in radiological emergencies*: Voluntary exposure of individuals who carry out an emergency intervention in order to help endangered individuals, prevent exposure of a large number of people, or save radiological installations or material goods, whereby an individual dose limit equal to that laid down for exposed workers could be exceeded.
- j) *Public exposure*: Exposure of members of the public, excluding occupational or medical exposure, and natural radiation but including exposure from authorized sources, practices, and intervention situations.
- k) *Equivalent dose ( $H_T$ )*: The absorbed dose  $D_{T,R}$  in tissue or organ T, multiplied by the appropriate radiation weighting factor  $w_R$  for the type and quality of radiation R. It is defined by the formula:

$$H_{T,R} = w_R D_{T,R}$$

where  $D_{T,R}$  the absorbed dose averaged over tissue or organ T, due to radiation R.

Appropriate values for  $w_R$  are given in Annex 2.

When the radiation field is composed of energies and radiation with different values of  $w_R$ , the total equivalent dose is given by:

$$H_T = \sum_R w_R D_{T,R}$$

The appropriate values for weighting factors are given in Annex 1. The unit for equivalent dose is the sievert (Sv).

- l) *Quality factor (Q)*: A function of linear energy transfer (L), used for multiplication of absorbed doses at one point so as to take the radiation quality into account.
- m) *Mean quality factor ( $\bar{Q}$ )*: Mean value of the quality factor at one point in a tissue where the absorbed dose is transferred through particles with different values of L. It is calculated using the formula:

$$\bar{Q} = \frac{1}{D} \int_0^{\infty} Q(L) D(L) dL$$

where  $D(L)dL$  is an absorbed dose at 10 mm between linear energy transfers  $L$  and  $L + dL$ , while  $Q(L)$  is a corresponding quality factor at the point of interest. Relations  $Q-L$  are given in Annex 1.

- n) *Fluence ( $\Phi$ )*: The quotient of  $dN$  divided by  $da$ , where  $dN$  is the number of particles that enter a sphere of cross-sectional area  $da$ :

$$\Phi = \frac{dN}{da}$$

- o) *Dose limits*: Maximum dose values resulting from the exposure of workers, apprentices, university students, and the population.

- p) *Gray (Gy)*: The unit of absorbed dose. One gray is equal to one joule by one kilogram:

$$1 \text{ Gy} = 1 \text{ J kg}^{-1}$$

- r) *Intervention*: An activity that prevents or decreases the exposure of individuals to radiation from the sources that are not part of a practice or that are out of control, by acting on sources, transmission pathways and individuals themselves.

- s) *Collective effective dose*: The total effective dose to the population, defined as:

$$S = \sum_i E_i N_i$$

where  $E_i$  is the average effective dose in the population subgroup  $i$ , while  $N_i$  is the number of individuals in the subgroup. The unit is the man-sievert.

- t) *Controlled area*: A radiation area in which specific protection measures and the compliance with safety provisions are required in exposures and prevention of contamination spread during normal working conditions, as well as prevention and restriction of potential exposures.

- u) *Apprentice, high-school or university student*: Any person receiving training or instructions within or outside of an institution in order to gain qualifications for a profession directly or indirectly related to the activities involving exposure.

- v) *Radiation protection officer*: An individual who is technically competent in a field of radiation protection relevant for a given practice, and designated by the authorization holder to apply the radiation protection measures.

- z) *Linear energy transfer ( $L_\infty$ )*: A quantity defined as:

$$L_\infty = \frac{dE}{dl}$$

where  $dE$  is the average energy lost by an energy particle  $E$  in traversing distance  $dl$  in the water. In this regulation,  $L_\infty$  is denoted by  $L$ .

- aa) *Supervised area*: A radiation area not designated as the controlled area and not requiring specific protection measures or special safety provisions although the occupational exposure conditions are controlled.
- bb) *Intervention level*: A value of avertable equivalent dose, avertable effective dose or a derived value serving as a basis for intervention measures during emergencies and lasting exposures.
- cc) *Investigation level*: The value of effective dose, intake or contamination per unit area or volume above which an additional investigation is needed.
- dd) *Recording level*: A level of dose, exposure or intake above which values of dose, exposure or intake received by exposed workers are to be entered in the register of individual doses.
- ee) *Authorization holder*: Any legal person authorized by the Agency for carrying out a practice involving sources.
- ff) *Nuclear facility*: A facility in which nuclear material is produced, processed, used, handled, stored or disposed of.
- gg) *Nuclear emergency*: An emergency in which there is a hazard due to the energy resulting from a nuclear chain reaction or the decay of the chain reaction products in nuclear reactors, nuclear fuel cycle facilities, radioactive waste management facilities or from transport or storage of nuclear fuel or radioactive waste.
- hh) *Committed effective dose  $[E(\tau)]$* : the sum of the committed organ or tissue  $H_T(\tau)$  equivalent doses, resulting from an intake, each multiplied by the appropriate tissue or organ weighting factor  $w_T$ , and defined by the formula:

$$E(\tau) = \sum_T w_T H_T(\tau)$$

When the  $\tau$  value is not specified, a period of 50 years is assumed for adults and up to the age 70 for children. The  $\tau$  value is given in the number of years over which the committed effective dose is calculated. The unit for committed effective dose is the sievert.

- ii) *Committed equivalent dose  $[H_T(\tau)]$* : The integral of the time of the equivalent dose in tissue or organ  $T$  that will be received by an individual as a result of an intake. It is defined by the formula:

$$H_T(\tau) = \int_{t_0}^{t_0+\tau} \dot{H}_T(t) dt$$

for an intake at time  $t_0$ , where  $\dot{H}_T(t)$  is the relevant equivalent dose rate at time  $t$  in organ or tissue T, and  $\tau$  is the time over which the integration is performed.

When the  $\tau$  value is not specified, a period of 50 years is assumed for adults and up to age 70 for children. The unit for committed equivalent dose is the sievert.

- jj) Disposal:* The emplacement of waste at a designated location without intention the intention of retrieval. Subject to the prior approval of the Agency, disposal also covers direct discharge of the waste into the environment and its subsequent dispersion.
- kk) Operational intervention level:* A level of dose rate that is calculated, measured by instruments or determined by laboratory analysis, that corresponds to an intervention level or action level.
- ll) Partial exposure:* An exposure that is essentially localized to one part of the body or to one or more organs or tissues, or an exposure of the whole body that is not considered homogeneous.
- mm) Personal dose equivalent  $H_p(d)$ :* The dose equivalent in soft tissue below a specified point on the body at an appropriate depth  $d$ . The special name for the unit of personal dose equivalent is the sievert (Sv).
- nn) Member of the public:* Any individual not subject to occupational or medical exposure and who represents an individual from the reference group whose exposure is homogenous and representative for the purpose of verifying compliance with the dose limits for the population.
- oo) Natural radiation sources:* Sources of ionizing radiation of natural terrestrial or cosmic origin.
- pp) Natural radiation:* A set of ionizing radiations emitted by natural terrestrial or cosmic sources to an extent where the resulting exposure is not significantly increased by human activities.
- rr) Exposed workers:* Persons who work with sources or who are within radiation fields in the course of their work, and who can be subject to an exposure resulting in doses above dose limits for the population.
- ss) Ambient dose equivalent  $H^*(d)$ :* 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  $d$  on the radius opposing the direction of the aligned field. The special name for the unit of ambient dose equivalent is the sievert (Sv).

tt) *Expanded and aligned field*: A radiation field in which the fluence, its directional and energy distribution are the same as in the expanded field, but the fluence is unidirectional.

uu) *Expanded field*: A field derived from the actual field, where fluence, its directional and energy distribution have the same values throughout the volume of interest as in the actual field at the point of reference.

vv) *Radiation emergency*: A nuclear or radiological emergency.

zz) *Radiological facility*: The facility where practices with sources are carried out.

aaa) *Radiological emergency*: An emergency in which there is a hazard of exposure to ionizing radiation in production, use, storage and disposal of radioactive sources during their application in agriculture, industry, medicine and scientific-research work.

bbb) *Radioactive contamination*: Undesirable presence of radioactive substances in the matter, on surfaces, in any environment or in an individual. On the human body the contamination can be external or dermal when found on body surface, or internal when radionuclides have entered the body by inhalation or ingestion, or through the skin, etc.

ccc) *Radioactive substance*: Any substance containing one or more radionuclides the activity or the activity concentration of which cannot be disregarded from the radiation protection point of view.

ddd) *Radioactive effluents*: Radioactive waste in liquid or gaseous form.

eee) *Reference group of the population*: A group of members of the public whose exposure is homogenous and representative of individuals who receive the highest dose from a given source.

fff) *Dose constraints*: Restrictions on the values of prospective individual doses delivered by a source and used in the planning of radiation protection for any circumstances where optimization should be considered.

ggg) *ICRU sphere*: A geometric body introduced by the International Commission on Radiation Units and Measurements (ICRU) to approximate the human body regarding energy absorption from ionizing radiation. It consists of a sphere of 30 cm in diameter, made of a tissue equivalent material with a density of  $1 \text{ g cm}^{-3}$  and a mass composition of 76.2% oxygen, 11.1% carbon, 10.1% hydrogen and 2.6% nitrogen.

hhh) *Radiation protection service*: An organizational unit within the authorized legal person that carries out the radiation protection tasks and is independent in relation to the organizational units where sources are used.

iii) *Sievert (Sv)*: The name for the unit of effective and equivalent doses. One sievert is equal to one joule by one kilogram:

$$1 \text{ Sv} = 1 \text{ J kg}^{-1}$$

*jjj) Population as a whole:* The whole population, including exposed workers, university and high-school students in training, and apprentices.

*kkk) Tissue or organ weighting factor ( $w_T$ ):* a dimensionless factor used to weight the equivalent dose in tissue or organ T. The appropriate  $w_T$  values are given in Annex 1.

*lll) Radiation weighting factor ( $w_R$ ):* a dimensionless factor used to weight absorbed dose in a tissue or an organ. The appropriate  $w_R$  values are given in Annex 1.

*mmm) Intake:* The activity of radionuclides taken into the body from the environment.

*nnn) Internal exposure:* Exposure of the body to a source within the body.

*ooo) Directional dose equivalent  $H'(d,\Omega)$ :* The dose equivalent at a point in the radiation field, which would be produced by the corresponding expanded field in the ICRU sphere at a depth  $d$  on a radius in specified direction  $\Omega$ . The special name for the unit of directional dose equivalent is the sievert (Sv).

*ppp) External exposure:* Exposure of the body to a source outside the body.

*rrr) Artificial radiation source:* Any source other than the natural source.

#### Article 4

#### **(Prohibition to add radioactive substances)**

The deliberate addition of radioactive substances in the production of foodstuffs, toys, personal ornaments and cosmetics, and also the import, export or transfer such goods containing radioactive substances shall be prohibited.

### **PART TWO – RADIATION PROTECTION PRINCIPLES**

#### **CHAPTER I. GENERAL PRINCIPLES OF RADIATION PROTECTION AND THE PRINCIPLES OF OPERATIONAL PROTECTION**

#### Article 5

#### **(Justification principle)**

- (1) Any existing or new practice resulting in exposure to ionizing radiation shall be justified in accordance with economic, social or other benefit in relation to the health detriment it may cause.
- (2) The Agency shall propose review of existing practices as to their justification whenever new and important evidence about their efficacy or consequences are acquired.

Article 6  
**(Optimization principle)**

Each practice shall be carried out so as to keep the exposure to ionizing radiation as low as reasonably achievable, economic and social factors being taken into account.

Article 7  
**(Dose limit principle)**

The sum of the doses from all practices shall not exceed the dose limits for exposed workers, apprentices, high-school and university students, and members of the public.

Article 8  
**(Application of general principles)**

- (1) The principles laid down in Articles 5, 6 and 7 shall apply to all exposures resulting from the practices referred to in Article 1(1).
- (2) The principle laid down in Article 7 shall not apply to the following exposures:
  - a) exposure of individuals within their own medical diagnostics or therapy,
  - b) exposure of individuals knowingly and willingly helping (other than as part of their occupation) patients undergoing medical diagnostics or therapy,
  - c) exposure of individuals voluntarily participating in medical and biomedical research programs.

**CHAPTER II. VALUES OF DOSE CONSTRAINTS, DOSE LIMITS  
AND REFERENCE LEVELS**

Article 9  
**(Dose constraints)**

- (1) In accordance with the optimization principle for radiation protection, the authorization holder shall use the following dose constraints:
  - a) for public exposure: 0.3 mSv in a year,
  - b) for occupational exposure: 2 mSv in a year.
- (2) The authorization holder may use lower values of dose constraints than those referred to in paragraph (1).

Article 10  
**(Application of dose limits)**

- (1) The dose limits shall apply to the sum of doses resulting from external exposure in a specified period and of committed doses resulting from the intake occurring in the same period.

- (2) The sum of doses referred to in paragraph (1) does not include doses resulting from natural radiation or from medical exposure.

#### Article 11

##### **(Dose limits for exposed workers)**

- (1) The limit on the effective dose for exposed workers shall be 20 mSv in a year.
- (2) In special circumstances, the Agency may authorize the dose of 50 mSv for an exposed worker in a single year, provided that the total dose over any five consecutive years shall not exceed the effective dose of 100 mSv.
- (3) The limit on the equivalent dose for the workers referred to in paragraph (1) shall be:
- a) for the lens of the eye: 20 mSv in a year,
  - b) for the skin: 500 mSv in a year, in which this limit shall apply to the average dose per 1 cm<sup>2</sup> regardless of the exposed area,
  - c) for the hands, forearms, feet and ankles: 500 mSv in a year.

#### Article 12

##### **(Dose limits for apprentices, high-school and university students)**

- (1) The limits on the effective dose for the apprentices, high-school and university students over 18 years of age who use sources in the course of their study or training shall be the same as the dose limits for the exposed workers referred to in Article 11(1).
- (2) The limit on the effective dose for the apprentices and high-school students between 16 and 18 years of age who use sources in the course of their education, study or training shall be 6 mSv in a year.
- (3) The limit on the equivalent dose for the individuals referred to in paragraph (2) shall be:
- 1) for the lens of the eye: 20 mSv in a year,
  - 2) for the skin: 150 mSv in a year, in which this limit shall be applied to the average dose per 1 cm<sup>2</sup> regardless of the exposed area,
  - 3) for the hands, forearms, feet and ankles: 150 mSv in a year.

#### Article 13

##### **(Dose limits for members of the public)**

- (1) The limit on the effective dose for members of the public shall be 1 mSv in a year.
- (2) The limits on the equivalent dose for members of the public shall be:
- a) for the lens of the eye: 15 mSv in a year,
  - b) for the skin: 50 mSv in a year, in which this limit shall apply to the average dose per 1 cm<sup>2</sup> regardless of the exposed area.

- (3) Collective effective dose for the population as a whole shall not exceed the value obtained by the multiplication of the total population number and the effective dose limit for members of the public.
- (4) The collective effective dose referred to in paragraph (3) shall include exposures of the population as a whole.

Article 14  
**(Reference levels)**

- (1) The value of registration level for personal dosimetry shall be 0.08 mSv in a month.
- (2) The value of investigation level for personal dosimetry shall be 1 mSv in a month.

**CHAPTER III. SPECIFIC REQUIREMENTS**

Article 15  
**(Special protection during pregnancy)**

- (1) The authorization holder shall ensure that female exposed workers report their pregnancy timely.
- (2) Fetal protection for the exposed workers referred to in paragraph (1) shall be comparable to the protection of members of the public.
- (3) The authorization holder shall ensure to the exposed workers referred to in paragraph (1) such working conditions that the equivalent dose for the fetus shall be as low as reasonably achievable, in which that dose shall not exceed 1 mSv until the end of pregnancy.
- (4) Having reported pregnancy, the exposed workers referred to in paragraph (1) shall be entitled to:
  - a) keep working in the same workplace as before reporting pregnancy,
  - b) request redeployment to another workplace where the exposure to ionizing radiation is lower than in the job position referred to in point a),
  - c) request redeployment to a workplace where they will not be exposed to ionizing radiation.
- (5) The authorization holder shall fulfill the requests referred to in paragraph (4), made by the pregnant workers referred to in paragraph (1), in which the holder shall not impose any conditions, exert pressure or discriminate against.
- (6) The Agency shall draw up the "Guide on the protection of exposed pregnant workers," which will be posted on the Agency's official web page, and it shall be binding for the authorization holders and the pregnant workers referred to in paragraph (1).

Article 16  
**(Special protection during breastfeeding)**

- (1) The authorization holder shall ensure that the exposed breastfeeding workers report their condition timely.
- (2) The authorization holder shall ensure that the breastfeeding workers referred to in paragraph (1) are not assigned any tasks involving a significant risk of internal and external radioactive contamination.
- (3) In the event that breastfeeding workers referred to in paragraph (1) are assigned the tasks that do not involve a significant risk of radioactive contamination, the authorization holder shall ensure the monitoring of possible radioactive contamination.
- (4) Upon request of the breastfeeding worker referred to in paragraph (1), the authorization holder shall ensure the same rights to her as the ones for the exposed workers referred to in Article 15.
- (5) The Agency shall draw up the "Guide on the protection of exposed breastfeeding workers," which will be posted on the Agency's official web page, and it shall be binding for the authorization holders and the breastfeeding workers referred to in paragraph (1).

**CHAPTER IV. ESTIMATION OF DOSES**

Article 17  
**(Estimation of effective and equivalent doses)**

The following shall be used for the estimation of effective and equivalent doses:

- a) For external exposure, the values and formulas given in the "Estimation Model for Effective and Equivalent Doses" shall be used to estimate appropriate effective and equivalent doses.
- b) For internal exposure arising from a single radionuclide or a mixture of several radionuclides, the values and formulas given in the "Estimation Model for Effective and Equivalent Doses" shall be used to estimate effective doses.

Article 18  
**(Estimation model for effective and equivalent doses)**

- (1) The Agency shall publish the "Estimation Model for Effective and Equivalent Doses," referred to in Article 17, on its official web page.
- (2) The data needed to calculate the doses under the Model referred to in paragraph (1) are given in Annexes 1, 2 and 3.

**PART THREE – OPERATIONAL PROTECTION OF EXPOSED WORKERS,  
APPRENTICES, HIGH-SCHOOL AND UNIVERSITY STUDENTS**

**CHAPTER I. OPERATIONAL PROTECTION PRINCIPLES**

Article 19

**(Operational protection principles for exposed workers)**

Operational protection of exposed workers shall be based on:

- a) An assessment of radiation safety, that is, a prior evaluation of working conditions to determine the nature and magnitude of the radiation risk and to ensure the implementation of the optimization principle,
- b) Classification of workplaces into different areas, taking into account the following:
  - 1) an assessment of committed annual doses,
  - 2) the risk of contamination dispersion,
  - 3) the probability and magnitude of potential exposures.
- c) Classification of exposed workers into different categories in accordance with working conditions,
- d) Implementation of control measures, and monitoring for different areas and different working conditions, including individual monitoring as necessary,
- e) Medical surveillance.

Article 20

**(Implementation of the principles)**

The authorization holder shall be responsible for the implementation of the principles referred to in Article 19.

**CHAPTER II. RADIATION SAFETY ASSESSMENT**

Article 21

**(Safety assessment)**

- (1) Before commencing a practice involving sources, any legal person shall conduct a prior assessment of the radiation safety in order to establish the measures required to restrict occupational exposure and public exposure.
- (2) In making the assessment referred to in paragraph (1), the legal person shall comply with the dose constraints referred to in Article 9.

Article 22  
**(Elements of the radiation safety assessment)**

- (1) The assessment referred to in Article 21 shall contain the following elements:
- a) data on the radiation type and energy for the devices producing ionizing radiation that are foreseen for use,
  - b) data on the type, energy and activity regarding the radioactive material foreseen for use,
  - c) an estimate of committed annual dose for exposed workers and the population,
  - d) an assessment of probability and possible spread of radioactive contamination,
  - e) recommendations of the equipment manufacturer regarding the safe use and maintenance,
  - f) a description of the foreseen work with the source,
  - g) an estimate of expected levels of contamination of air and surfaces,
  - h) a needs assessment regarding personal protective equipment, including an assessment of efficiency and appropriateness of the equipment,
  - i) the definition of controlled and supervised areas.
- (2) The elements referred to in paragraph (1) shall be an integral part of the radiation safety assessment only if they are relevant for carrying out a given practice involving sources.

Article 23  
**(Review of the safety assessment)**

The authorization holder shall review the radiation safety assessment in the following cases:

- a) Significant change of carrying out the practice, which includes:
  - 1) the introduction of sources of a higher category than the existing one in accordance with the categorization laid down in the Regulation on the notification and authorization of the practices involving ionizing radiation sources ("Official Gazette of BiH" 66/10),
  - 2) the introduction of radioactive sources emitting different types or quality of radiation,
  - 3) the introduction of equipment producing radiation of much higher energy than the existing radiation,
  - 4) the introduction of open sources to the premises where sealed sources were used earlier,
  - 5) a modification of the installation, including changes of control and security mechanisms,
  - 6) a change of a work process or method,
  - 7) a change of staff structure.
- b) If the results of personal dosimetry or monitoring of the workplace significantly deviate from the anticipated ones.

## **CHAPTER III. PREVENTION OF EXPOSURE**

### **Section A. Classification and labeling of areas**

#### Article 24

##### **(Designation of areas)**

- (1) Under the applicable legislation on radiation safety and nuclear security, the authorization holder shall designate and label all workplaces where there is a possibility that an individual receive an effective dose of more than 1 mSv in a year or an equivalent dose of more than 15 mSv in a year for the lens of the eye, or an equivalent dose of more than 50 mSv in a year for the skin or hands, forearms, feet and ankles, and the authorization holder shall establish applicable radiation protection measures.
- (2) The measures referred to in paragraph (1) shall be appropriate to the type of facilities and sources, and to the magnitude and nature of risk.
- (3) The scope of the prevention and monitoring measures, and their type and quality shall be appropriate to the risk associated with the tasks involving exposure.

#### Article 25

##### **(Classification of areas)**

- (1) The authorization holder shall classify workplaces into controlled areas and supervised areas in accordance with the exposure risk, taking into account the probability and magnitude of potential exposures.

#### Article 26

##### **(Controlled and supervised areas)**

- (1) Exposure of the individual in the controlled area may exceed an effective dose of 6 mSv in a year or an equivalent dose of 15 mSv in a year for the lens of the eye, or an equivalent dose of 150 mSv in a year for the skin or hands, forearms, feet and ankles.
- (2) The authorization holder shall ensure the implementation of special work procedures in the controlled area referred to in paragraph (1), with the aim of restricting exposures, avoiding the dispersion of radioactive contamination, or preventing or limiting the probability and magnitude of radiological accidents or their consequences.
- (3) The supervised area is an area where there is a probability that the exposure of an individual may exceed an annual effective dose of 1 mSv in a year or an equivalent dose of 15 mSv in a year for the lens, or an equivalent dose of 50 mSv in a year for the skin or hands, forearms, feet and ankles.
- (4) Based on an expertise from a radiation protection expert, the authorization holder shall revise the area classification if work conditions have changed.

- (5) The Agency shall draw up the "Guide for the classification of controlled and supervised areas," which will be posted on the Agency's official web page, and it shall be binding for the authorization holders.

#### Article 27

##### **(Area requirements)**

- (1) Taking into account the nature and magnitude of the radiation risk, the authorization holder shall ensure dose monitoring in the workplace in controlled and supervised areas in accordance with Annex 5.
- (2) In the controlled areas where there is a risk of:
  - a) external exposure, the use of individual dosimeters shall be mandatory.
  - b) contamination, the use of personal protective equipment in accordance with a given risk shall be mandatory. Appropriate detectors must be installed at the exit of the areas to check for possible contamination of individuals and equipment in order to take appropriate measures should the contamination be detected.
- (3) The estimation of doses in supervised areas shall be conducted through the monitoring of the workplace.

#### **Section B. Categorization of exposed workers**

#### Article 28

##### **(Age limits for exposed workers)**

Apprentices and high-school students between 16 and 18 years of age may not be assigned a task normally performed by exposed workers.

#### Article 29

##### **(Categorization of exposed workers)**

- (1) Based on an expertise from a radiation protection expert, the authorization holder shall categorize exposed workers into category A and category B for the purpose of personal monitoring and medical surveillance.
- (2) The category A shall include the exposed workers who, because of their working conditions, may receive an effective dose of more than 6 mSv in a year or an equivalent dose of 15 mSv in a year for the lens of the eye or an equivalent dose of 150 mSv in a year for the skin or hands, forearms, feet and ankles.
- (3) The category A shall include the exposed workers who are not categorized as category A exposed workers.

## **Section C. Information and training**

### **Article 30 (Information)**

The authorization holder shall inform exposed workers, apprentices, high-school and university students who use sources in the course of their studies about:

- a) the radiological risks, and technical, medical and administrative requirements,
- b) the rules and procedures of radiation protection, and precaution measures they shall take in respect of both the practice in general and a type of job they may be assigned.

### **Article 31 (Training)**

The authorization holder shall provide to exposed workers, apprentices, high-school and university students an appropriate training in radiation protection, the level of which shall be in accordance with their respective responsibilities and exposure risk at the workplace.

## **Section D. Assessment and implementation of radiation protection measures**

### **Article 32 (Implementation of radiation protection measures for exposed workers)**

- (1) The authorization holder shall be responsible for assessing and implementing the radiation protection measures for exposed workers.
- (2) During the testing of protective devices and measuring instruments the authorization holder shall obtain an expert opinion from a radiation protection expert, comprising in particular:
  - a) prior critical examination of installation plans from the point of view of radiation protection,
  - b) the acceptance into service of new or modified sources from the point of view of radiation protection,
  - c) regular checking of the effectiveness of protective devices and techniques,
  - d) regular calibration, check of condition and proper use of measuring instruments.

### **Article 33 (Radiation protection service)**

- (1) The holder of authorization for specific medical practices of radiotherapy, nuclear medicine and diagnostic radiology shall establish a radiation protection service as a separate organizational unit in relation to the departments for the above-mentioned specific practices.

- (2) The radiation protection service shall perform the duties and provide expert advice in the field of radiation protection under Article 34(2).
- (3) The radiation protection service shall employ at least one radiation protection expert who is authorized and performs the duties of the radiation protection officer as defined in the Regulation on the conditions for transfer and use of ionizing radiation sources ("Official Gazette of BiH" no. 66/10).
- (4) The medical physics service, as defined in the Regulation on the ionizing radiation protection in medical exposure ("Official Gazette of BiH" 13/11), may perform duties of the radiation protection service for the authorization holders referred to in paragraph (1).
- (5) As for all practices involving the ionizing radiation sources not listed in paragraph (1), the Agency, taking into account the radiation risk and the complexity of a practice, shall estimate on a case-by-case basis whether an authorization holder will establish a radiation protection service.
- (6) The authorization holder that has not established a radiation protection service shall engage an appropriate technical service that performs jobs and provides expert advice in the field of radiation protection, taking into account the radiation risk and the complexity of a practice.

#### Article 34

#### **(Responsibilities of the radiation protection expert)**

- (1) On the basis of professional judgment, measurements and assessments, the radiation protection expert shall give expert advice to the authorization holder on the matters related to occupational exposure and public exposure.
- (2) The expert opinion referred to in paragraph (1) shall refer to the following:
  - a) plans for new radiological installations and the acceptance into service of new or modified radiation sources in relation to any engineering controls, design features, source safety features and warning devices relevant to radiation protection,
  - b) the classification of controlled and supervised areas,
  - c) the categorization of workers,
  - d) the content of workplace and individual monitoring,
  - e) the appropriate radiation monitoring instrumentation to be used,
  - f) the appropriate methods of personal dosimetry,
  - g) the optimization and establishment of appropriate dose constraints,
  - h) quality assurance and control, excluding quality assurance and control for medical practices,
  - i) the environmental monitoring program,
  - j) radioactive waste disposal requirements,
  - k) the procedures for prevention of accidents and incidents, and for preparedness and response plan in emergencies,

- l) training for exposed workers,
- m) other matters regarding radiation protection.

## **CHAPTER IV. ASSESSMENT OF EXPOSURE**

### **Section A. Monitoring of the workplace**

#### Article 35 **(Monitoring of the workplace)**

Monitoring of the workplace shall cover the measurement of:

- a) dose rates, specifying the nature and quality of the radiation in question,
- b) air activity concentration and surface contamination, specifying the nature of radioactive substances and their physical and chemical states, in the work with open sources,
- c) Radon concentration in the workplace in potential exposure to natural sources.

#### Article 36 **(Records and record keeping)**

- (1) The documents related to the recording, assessment and results of the monitoring referred to in Article 35 shall be archived by the authorization holder.
- (2) The measurement results referred to in Article 35 shall be used to estimate individual doses and shall be kept in the authorization holder's archive for at least 5 (five) years.

### **Section B. Individual monitoring**

#### Article 37 **(Individual monitoring)**

- (1) The external and internal individual dosimetry control shall be conducted by a technical service for individual monitoring, licensed by the Agency.
- (2) The technical service referred to in paragraph (1) shall send a report on the measurement of individual doses to the authorization holder and the Agency.
- (3) While referring exposed workers to a medical surveillance, the authorization holder shall send the results of dosimetry controls for previous period to the technical service for medical surveillance of exposed workers.
- (4) In the case of a radiation accident or an emergency, the results referred to in paragraph (2) shall be immediately sent to the authorization holder and the Agency.

Article 38

**(Dose estimates for exposed workers of A and B categories)**

- (1) The following shall be mandatory for exposed workers of A and B categories:
  - a) the use of passive personal dosimeters for measuring the external dose, representative for the whole-body dose during all working hours, in the case of an external exposure,
  - b) the use of appropriate dosimeters for the potentially most affected body parts, in the case of risk of a partial or non-uniform external exposures (lens of the eye, and hands),
  - c) the conduct of relevant measurements or analyses to evaluate the corresponding dose, in the case of risk of internal contamination.
- (2) The magnitude of external exposure of exposed workers categories A and B shall be measured by passive personal dosimeters, with a one-month reading period.
- (3) The reading period referred to in paragraph (2) for category B workers may be longer than one month but not exceeding three months, the decision on which shall be made by the Agency, depending on the radiation risk and the complexity of a given practice.

Article 39

**(Special estimates of doses)**

- (1) Where individual dose measurements are not possible or applicable, the individual monitoring shall be based on an estimate arrived at either from individual measurements made on other exposed workers or from the results of monitoring of the workplace.
- (2) The measurements referred to in paragraph (1) shall be kept in the register of individual doses for occupationally exposed workers.

Article 40

**(Monitoring of accidental and emergency exposures)**

- (1) In the event of accidental exposure, the dose and its distribution in the body shall be assessed.
- (2) In the event of emergency exposure, individual monitoring or assessment of individual doses shall be carried out.

Article 41

**(Exceeding the dose limits)**

- (1) Where the dose limits laid down in Article 11 are exceeded as a result of specially authorized exposure due to an accident or emergency, the authorization holder shall

assess as soon as possible the received doses for the whole body or for individual affected tissues or organs.

- (2) The authorization holder shall immediately inform the Agency, technical service for medical surveillance of exposed workers, and the exposed worker in person about the situations referred to in paragraph (1) .

### **Section C. Specially authorized exposures**

#### Article 42

#### **(Authorization of exposures)**

- (1) Exposures exceeding the prescribed dose limits for exposed workers may be authorized only in exceptional circumstances, when normal working conditions do not allow for a possibility of an alternative action to keep the exposure for workers within the prescribed limits.
- (2) The exposures referred to in paragraph (1) shall be kept below the limits established for each individual situation for which an exposure is specially authorized.
- (3) The exposures referred to in paragraph (1) shall be approved by the Agency on the basis of prior expert opinion of a technical service for radiation protection or a radiation protection expert.
- (4) The exposures referred to in paragraph (1) shall be authorized only for category A workers who voluntarily accept such an exposure, taking into account their age and health condition.
- (5) The exposures referred to in paragraph (1) shall be justified in advance, while the persons undergoing such exposures shall be informed about the risk involved and the measures to be taken during such exposures.
- (6) A person for whom an exposure is specially authorized need not be excluded from usual working tasks if a technical service for medical surveillance of exposed workers has assessed so.

#### Article 43

#### **(Restrictions)**

The exposures referred to in Article 42 shall not be approved to:

- a) the persons who in the previous 12-month period received an effective or equivalent dose above prescribed dose limits,
- b) pregnant women, breastfeeding women, minors and university students.

Article 44  
**(Records)**

The authorization holder shall keep records about the doses received by exposed workers during the specially authorized exposure.

**Section D. Recording and informing of results**

Article 45  
**(Register of individual doses)**

- (1) The authorization holder shall keep the register of received doses during the career of each exposed worker.
- (2) Exposed workers shall be permitted to access the register of received doses referred to in paragraph (1).

Article 46  
**(Contents of the register of individual doses)**

- (1) The register of individual doses of exposed workers shall contain recorded monthly doses, the doses accumulated over the calendar year, and the doses accumulated over the period of 5 (five) consecutive years.
- (2) The register referred to in paragraph (1) shall contain the year–period, the effective dose in mSv, appropriate dose equivalents in mSv for body parts in the event of non-uniform exposures, and the committed dose in mSv in the event of internal contamination.

Article 47  
**(Recording doses arising from accidents or emergencies)**

The dose received due to an accident or emergency shall be recorded into the register of individual doses separately from the doses received during the work in normal conditions.

Article 48  
**(Employment with more than one authorization holder)**

If an exposed worker is employed with two or more authorization holders, each authorization holder shall provide a personal dosimeter to the worker.

Article 49  
**(Archiving of the documentation)**

- (1) The authorization holder shall keep in the archive the register of individual doses for the exposed workers until the individual has attained the age of 75 years, and at least 30 years from the date of termination of the work.

- (2) After the exposed worker has terminated the work, the authorization holder shall provide the worker a certified copy of his or her register of individual doses.

#### **PART FOUR – RADIATION PROTECTION OF THE POPULATION UNDER NORMAL CIRCUMSTANCES**

##### Article 50 **(General principles)**

Protection of the members from the public and the whole population shall be based on the principles laid down in Articles 5, 6 and 7.

##### Article 51 **(Implementation of the radiation protection measures for the population)**

In normal circumstances, the Implementation of the measures of radiation protection from the previously authorized practices shall imply all obligations and measurements in order to identify and eliminate the factors involving exposure that may lead to such a risk for the population that cannot be disregarded from the radiation protection point of view.

##### Article 52 **(Discharge of radioactive effluents)**

- (1) The Agency shall issue approval to the authorization holder for any discharge of radioactive effluents into the environment.
- (2) The authorization holder shall previously notify the Agency of the intention to discharge radioactive effluents into the environment.

##### Article 53 **(Effluent discharge levels)**

- (1) The activity levels for the discharge of radioactive effluents into the environment shall be such that the activity concentration of the radionuclides contained in them and the values of population doses shall be as low as reasonably achievable, taking into account economic and social factors.
- (2) The activity levels referred to in paragraph (1) shall always be lower than the population doses referred to in Article 13, and in special cases lower than other lower values determined by the Agency.

##### Article 54 **(Estimation of doses received by the population)**

- (1) The authorization holder that discharges radioactive effluents into the environment shall regularly estimate doses received by the whole population, and for reference groups as well.

- (2) The results of estimates referred to in paragraph (1), which shall be carried out at least once a year for reference groups, shall be submitted to the Agency.
- (3) The dose estimates referred to in paragraph (1) include:
  - a) assessment of external exposures, indicating, where necessary, the type and characteristics of the radiation,
  - b) assessment of the intake of radionuclides, indicating the nature of the radionuclides and, where appropriate, their physical and chemical states, and the determination of the activity and concentrations of these radionuclides,
  - c) specification of the characteristics of reference groups of the population.

Article 55  
**(Record keeping)**

- (1) The authorization holder discharging radioactive effluents into the environment shall keep the documents relating to measurements of external exposure, estimates of intakes of radionuclides and radioactive contamination, as well as the results of the assessment of the doses received by reference groups and by the whole population.
- (2) The documents referred to in paragraph (1) of this Article shall be kept at least five years.

Article 56  
**(Storage of radioactive effluents)**

- (1) The authorization holder shall store radioactive effluents in the containers the properties of which shall ensure sufficient protection from ionizing radiation, taking into account the conditions of the storage location and possible dispersion or leakage of radioactive material.
- (2) The containers used for the storage of radioactive effluents shall be labeled under the applicable legislation.
- (3) The authorization holder shall keep records on the most important physical and chemical properties, contents of the containers with radioactive effluents, and at least the maximum level of exposure during the contact and at 1 m distance from the area, the date of last measurement and, if possible, the activity.

Article 57  
**(Responsibility)**

With the aim of protecting the whole population, the authorization holder shall pay special attention within the facility where a practice is carried out to:

- a) achieving and maintaining an optimal level of protection of the environment and the population,

- b) checking the effectiveness of technical devices for protecting the environment and the population,
- c) using the necessary equipment and conducting measurement procedures for the radiation protection of the population and the environment and, as appropriate, assessing the exposure and radioactive contamination of the environment and the population,
- d) regular calibration, verification and check of serviceability and functioning of measuring instruments.

## **PART FIVE – INTERVENTIONS**

### **Article 58 (Principles of intervention)**

The intervention shall be based on the following principles:

- a) any intervention shall be justified so that the benefit achieved by reducing radiological detriment, that is, the dose, is higher than the costs of intervention and the harm an intervention may cause, including social effects.
- b) the form, scale and duration of the intervention shall be optimized so that the benefit of the intervention be maximized,
- c) the dose limits for exposed workers and the population shall not apply to intervention,
- d) dose limits for exposed workers shall apply to workers involved in interventions in the case of lasting exposures.

### **Article 59 (System of protective actions in emergencies)**

- (1) The system of protective actions in emergencies shall include numerical values of generic criteria, and as well the corresponding operational criteria that form the basis for implementing the actions in emergencies.
- (2) The system referred to in paragraph (1) is given in table 4 in Annex 4.

### **Article 60 (Exposures in radiological or nuclear emergencies)**

- (1) The levels of exposure in radiological or nuclear emergencies are given in Annex 4.
- (2) The intervention in radiological or nuclear emergencies shall be implemented by exposed workers only.
- (3) In radiological or nuclear emergencies the exposures above the levels defined in Annex 4 may be approved in order to save human lives, provided that those exposed are volunteers who shall be informed in advance about all risks of such interventions.

- (4) Volunteers involved in the intervention in radiological or nuclear emergencies shall undergo a dosimetry control and a special medical surveillance conducted by an authorized technical service.
- (5) Having completed the intervention in radiological or nuclear emergencies, the volunteers shall be referred to medical surveillance, informed about the measured total exposure dose and about the assessed relevant risk.

#### Article 61

##### **(Exposure of volunteers above limits)**

A volunteer involved in the intervention in radiological or nuclear emergencies may be exposed to a dose above the limits prescribed for exposed workers only in the following cases:

- a) saving lives or preventing serious injuries,
- b) preventing an excessive exposure of a large number of people,
- c) preventing an emergency of a large or catastrophic scale.

#### Article 62

##### **(General criteria)**

The general criteria for the implementation of protective measures are given in tables 5 and 6 in Annex 4.

#### Article 63

##### **(Application of intervention in lasting exposures)**

- (1) For the intervention in lasting exposures the Agency shall, to the extent of the exposure risk involved, ensure that:
  - a) the area is demarcated,
  - b) arrangements for the monitoring of exposure are made,
  - c) appropriate interventions are made, taking into account the characteristics of a lasting exposure,
  - d) access to and use of the land and buildings situated in the demarcated area is regulated.
- (2) The action levels in lasting exposures above which the intervention shall be justified and mandatory are given in table 7 in Annex 4.

#### Article 64

##### **(Concentration of radon in the workplace)**

The action level for corrective measures in lasting exposures to radon in the workplace shall be equal to average annual concentration of  $1000 \text{ Bq m}^{-3}$  of Rn-222 in the air.

Article 65  
**(Default safe distance)**

The suggested radii of the cordoned area in radiological or nuclear emergencies are given in table 8 in Annex 4.

Article 66  
**(Operational intervention levels for field survey measurements)**

The suggested operational intervention levels in radiological or nuclear emergencies for field survey measurements are given in table 9 in Annex 4.

Article 67  
**(Operational intervention levels for food)**

The suggested operational intervention levels for food, milk, and water in radiological or nuclear emergencies are given in tables 10 and 11 in Annex 4.

Article 68  
**(Restrictions in interventions)**

Restrictions of the personal dose equivalent for the exposed workers involved in interventions are given in table 12 in Annex 4.

**PART SIX – NATURAL SOURCES**

Article 69  
**(Exposure to natural sources)**

- (1) The Agency may require the holders of authorization for the practices not laid down in Article 1(2) but involving natural sources to conduct necessary investigations to determine whether there is a significant increase in the exposure of workers or the population that cannot be disregarded from the radiation protection point of view.
- (2) The work activities that shall be subject to the investigations referred to in paragraph (1) are:
  - a) activities where workers and the population can be exposed to the inhalation of thoron or radon daughters or gamma radiation or any other exposure in workplaces such as thermal sources, caves, mines, underground workplaces or aboveground workplaces in identified areas,
  - b) activities involving storage or handling the materials that are usually not considered radioactive but contain natural radionuclides causing a significant increase in the exposure of workers and the population,
  - c) activities leading to the production of the waste that is usually not considered radioactive but contains natural radionuclides causing a significant increase in the exposure of workers and the population,

- d) activities involving exposure to cosmic radiation during flights.

Article 70  
**(Work activities)**

- (1) An authorized technical service shall conduct the tests referred to in Article 69 and submit to the Agency the test results, based on which the Agency shall determine the work activities that will require special attention and further control.
- (2) On the basis of the investigations referred to in Article 69, the Agency shall define the work activities that will require corrective measures to reduce the exposure, and other radiation protection measures.

Article 71  
**(Aircrews)**

The airliners whose aircrews may receive an effective dose from cosmic radiation of more than 1 mSv in a year shall engage an authorized technical service to carry out the following activities:

- a) assessment of the exposure of the aircrew members,
- b) provision of information to the aircrew members about possible radiological risks,
- c) application of Article 15 to female aircrew members.

**PART SEVEN – ASSESSMENT OF EXPOSURES TO IONIZING RADIATION**

Article 72  
**(Calculation of effective dose)**

The effective dose  $E$  incurred by an individual in the age group  $g$  shall be calculated under the following formula:

$$E = E_{\text{external}} + \sum_j h(g)_{j,\text{ing}} J_{j,\text{ing}} + \sum_j h(g)_{j,\text{inh}} J_{j,\text{inh}}$$

where:

- $E_{\text{external}}$  – the relevant effective dose from external exposure,
- $h(g)_{j,\text{ing}}$  and  $h(g)_{j,\text{inh}}$  – the committed effective dose per unit-intake of ingested or inhaled radionuclide  $j$  (Sv/Bq) by an individual in the age group  $g$ ,
- $J_{j,\text{ing}}$  and  $J_{j,\text{inh}}$  – relevant intakes via ingestion and inhalation of the radionuclide  $j$  (Bq).

Article 73  
**(Methodology)**

The assessment of occupational exposure and public exposure shall be conducted on the basis of results of the control of external and internal exposures, under the Methodology of measurement and assessment of exposure given in Annex 5.

**PART EIGHT – TRANSITIONAL AND FINAL PROVISIONS**

Article 74  
**(Recognition of qualifications of the radiation protection expert)**

Until the adoption of the regulations recognizing qualifications of the radiation protection expert, the Agency shall establish a commission tasked with drawing up the criteria for assessing qualifications of an individual to act as the radiation protection expert referred to in Article 34.

Article 75  
**(Harmonization of regulations)**

Legal persons carrying out the practice involving sources shall harmonize their operations with the provisions of this regulation within one year from the day of entering this regulation into force.

Article 76  
**(Accountability for non-compliance with the provisions of this regulation)**

Any non-compliance with the provisions of this regulation shall be punished under the penalty provisions of the Law on Radiation and Nuclear Safety in Bosnia and Herzegovina ("Official Gazette of BiH" 88/07).

Article 77  
**(Entering into force)**

This regulation shall enter into force on the eighth day following that of its publication in the "Official Gazette of BiH."

**DIRECTOR**

**Emir Dizdarević**

No: 01-02-1103/11/11  
Sarajevo, 15 December 2011

## ANNEX 1. Estimated doses due to external exposure

Values of radiation weighting factor  $w_R$ , depend on the type and quality of the external radiation field or on the type and quality of the radiation emitted by an internally deposited radionuclide.

**Table 1: Radiation weighing factors  $w_R$**

Radiation type	Radiation weighting factor, $w_R$
Photons, all energies	1
Electrons and muons	1
Protons and charged pions	2
Alpha particles, fission fragments, heavy ions	20
Neutrons	A continuous curve as a function of neutron energy

A continuous curve as a function of neutron energy is:

$$w_R = \begin{cases} 2.5 + 18.2 e^{-\frac{[\ln(E_n)]^2}{6}}, & E_n < 1 \text{ MeV} \\ 5.0 + 17.0 e^{-\frac{[\ln(2 E_n)]^2}{6}}, & 1 \text{ MeV} \leq E_n \leq 50 \text{ MeV} \\ 2.5 + 3.25 e^{-\frac{[\ln(0.04 E_n)]^2}{6}}, & E_n > 50 \text{ MeV} \end{cases}$$

where  $E_n$  is the neutron energy in MeV.

**Table 2: Relationship between the quality factor,  $Q(L)$ , and unrestricted linear energy transfer,  $L$**

Unrestricted linear energy transfer, $L$ in water ( $\text{keV } \mu\text{m}^{-1}$ )	$Q(L)$
< 10	1
10-100	$0,32 L^{-2,2}$
>100	$300/\sqrt{L}$

**Table 3: Values of weight factors of tissue or organ,  $w_T$**

Tissue or organ	$w_T$	$\sum w_T$
Bone marrow, colon, lung, stomach, breast, remainder*	0,12	0,72
Gonads	0,08	0,08
Bladder, oesophagus, liver, thyroid	0,04	0,16
Bone surface, brain, salivary glands, skin	0,01	0,04
	In total	1.00

\*The specified remainder tissues are: adrenals, extrathoracic tissue (ET), gall bladder, heart, kidneys, lymphatic nodes, muscle, oral mucosa, pancreas, prostate, small intestine (SI), spleen, thymud, uterus/cervix.

## ANNEX 2. Operational quantities for external radiation

Operational quantities for external radiation are used for individual monitoring for radiation protection purposes:

### 2.1. Individual monitoring:

- personal dose equivalent  $H_p(d)$ ,
- $d$ : depth in mm in the body.

### 2.2. Area monitoring:

- ambient dose equivalent  $H^*(d)$ ,
- directional dose equivalent  $H'(d, \Omega)$
- $d$ : depth in mm under the surface of the ICRU sphere,
- $\Omega$ : angle of incidence.

For strongly penetrating radiation a depth of 10 mm, for weakly penetrating radiation a depth of 0,07 mm for the skin and 3 mm for the eye is recommended.

### **ANNEX 3. Estimation of dose due to internal exposure**

**3.1** In this regulation requirements on doses apply to the sum of the relevant doses from external exposure in a specified period and the relevant 50-year (fifty) committed doses (up to age 70 /seventy/ for children) from intakes in the same period.

**3.2** Except for radon progeny and thoron progeny, values of the committed effective dose for unit intake for ingestion and inhalation are given for members of the public and for apprentices and students aged between 16 and 18 years in the Model for estimating the effective dose.

**3.3** Except for radon progeny and thoron progeny, values of the committed effective dose for unit intake for ingestion and inhalation are given for exposed workers and for apprentices and students aged 18 years or more in the Model for estimating the effective dose.

**3.4** For radon progeny and thoron progeny the following conventional conversion factors apply, effective dose per unit potential alpha-energy exposure (Sv/ (J.h.m<sup>-3</sup>)):

- Radon (<sup>222</sup>Rn) at work: 1,4
- Thoron (<sup>220</sup>Rn) at work: 0,5

Potential alpha energy (of radon progeny and thoron progeny): The total alpha energy ultimately emitted during the decay of radon progeny and thoron progeny through the decay chain, up to but not including <sup>210</sup>Pb for progeny of <sup>222</sup>Rn and up to stable <sup>208</sup>Pb for progeny of <sup>220</sup>Rn. The unit is J (Joule). For the exposure to a given concentration for a given time the unit is J.h.m<sup>-3</sup>.

## ANNEX4. Criteria for response to emergency events)

**Table4: System of protective actions and other response actions in an emergency**

Types of possible health consequences of exposure	Basis for implementation of protective actions and other response actions	
	Projected dose	Dose received
Severe deterministic effects <sup>a</sup>	Implementation of precautionary urgent protective actions, even under adverse conditions, to prevent severe deterministic effects	Other response actions <sup>b</sup> for treatment and management of severe deterministic effects
Increase in stochastic effects	Implementation of urgent protective actions and initiation of early protective actions <sup>c</sup> to reduce the risk of stochastic effects as far as reasonably possible	Other response actions <sup>d</sup> for early detection and effective management of stochastic effects

<sup>a</sup>Generic criteria are established at levels of dose that are approaching the thresholds for severe deterministic effects.

<sup>b</sup>Such actions include immediate medical examination, consultation and treatment as indicated, contamination control, decorporation where applicable, registration for long term health monitoring, and comprehensive psychological counselling.

<sup>c</sup>Such actions include relocation and long term restriction of consumption of contaminated food.

<sup>d</sup>Such actions include screening based on individual doses to specific organs, considering the need for registration for medical follow-up and counselling to allow informed decisions to be made in individual circumstances.

**Table5: Generic criteria for acute doses for which protective actions and other response actions are expected to be taken under any circumstances to avoid or to minimize severe deterministic effects**

Generic criteria		Examples of protective actions and other response actions
External acute exposure (<10 hours)		
$AD_{\text{Red marrow}}$ $AD_{\text{Fetus}}$ $AD_{\text{Tissue}}^a$ $AD_{\text{Skin}}^b$	1 Gy 0,1 Gy 25 Gy at 0,5 cm 10 Gy to 100 cm <sup>2</sup>	If the dose is projected: <ul style="list-style-type: none"> <li>– Take precautionary urgent protective actions immediately (even under difficult conditions) to keep doses below the generic criteria</li> <li>– Provide public information and warnings</li> <li>– Carry out urgent decontamination</li> </ul>
Internal exposure from acute intake ( $\Delta = 30$ days)		
$AD(\Delta)_{\text{Red marrow}}$	0,2 Gy for	If the dose has been received:

$AD(\Delta)_{\text{Thyroid}}$ $AD(\Delta)_{\text{Lung}}$ $AD(\Delta)_{\text{Colon}}$ $AD(\Delta')_{\text{Fetus}}^d$	radionuclides with $Z \geq 90$ 2 Gy for radionuclides with $Z \leq 89$ 2 Gy 30 Gy 20 Gy 0,1 Gy	— Perform immediate medicalexamination, consultation and indicatedmedical treatment — Carry out contamination control — Carry out immediate decorporation <sup>c</sup> (if applicable) — Carry out registration for long term health monitoring (medical follow-up) — Provide comprehensive psychologicalcounselling
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Remark (ili footnote):  $AD_{\text{Red marrow}}$  represents the average RBE weighted absorbed dose to internal tissues or organs(e.g. red marrow, lung, small intestine, gonads, thyroid) and to the lens of the eye from exposure in a uniform field of strongly penetrating radiation;  $AD(\Delta)$  is the RBE weighted absorbed dose delivered over the period of time  $\Delta$  by the intake ( $I_{05}$ ) that will result in a severe deterministic effect in 5% of exposed individuals (RBE factor values given in the IAEA publication "Safety Standards No.GSG-2: Criteria for Use in Preparedness and Response for a Nuclear or Radiological Emergency", in table 6 on page 25).

<sup>a</sup>Dose delivered to 100 cm<sup>2</sup> at a depth of 0.5 cm under the body surface in tissue due to close contact with a radioactive source (e.g. source carried in the hand or pocket).

<sup>b</sup>The dose is to the 100 cm<sup>2</sup> dermis (skin structures at a depth of 40 mg/cm<sup>2</sup> (or 0.4 mm) below the body surface).

<sup>c</sup> Decorporation is the biological processes, facilitated by a chemical or biological agent, by which incorporated radionuclides are removed from the human body.

<sup>d</sup>For this particular case,  $\Delta'$  means the period of in utero development.

**Table6: Generic criteria for protective actions and other response actions in emergency exposure situations to reduce the risk of stochastic effects**

Generic criteria	Examples of protective actions and other response actions
Projected dose that exceeds the following generic criteria: Take urgent protective actions and other response actions	
$H_{\text{Thyroid}}$ 50 mSv in the first 7 days	Iodine thyroid blocking
E 100 mSv in the first 7 days $H_{\text{Fetus}}$ 100 mSv in the first 7 days	Sheltering; evacuation; decontamination; restriction of consumption of food, milk and water; contamination control; public reassurance
Projected dose that exceeds the following generic criteria: Take protective actions and other response actions early in the response	
E 100 mSv per annum $H_{\text{Fetus}}$ 100 mSv for the full period of in utero development	Temporary relocation; decontamination; replacement of food, milk and water; public reassurance
Dose that has been received and that exceeds the following generic criteria: Take longer term medical actions to detect and to effectively treat radiation induced health effects	
E 100 mSv in a month	Screening based on equivalent doses to specific radiosensitive organs (as a basis

	for medical follow-up); counselling
$H_{\text{Fetus}}$ 100 mSv for the full period of in utero development	Counselling to allow informed decisions to be made in individual circumstances

**Note:**  $H_T$ — equivalent dose in an organ or tissue  $T$ ;  $E$  — effective dose.

**Table 7: Equivalent dose rate interventional levels for lasting exposures**

Organ or tissue	Equivalent dose rate (Sv per annum)
Gonads	0,2
Eye lens	0,1
Bone marrow	0,4

**Table 8: Suggested radius of the inner cordoned area (safety perimeter) in a nuclear or radiological emergency**

Situation	Initial inner cordoned area (safety perimeter)
<i>Initial determination — Outside</i>	
Unshielded or damaged potentially dangerous source	30 m radius around the source
Major spill from a potentially dangerous source	100 m radius around the source
Fire, explosion or fumes involving a dangerous source	300 m
Suspected bomb (possible radiological dispersal device), exploded or unexploded	400 m radius or more to protect against an explosion
Conventional (non-nuclear) explosion or a fire involving a nuclear weapon (no nuclear yield)	1000 m
<i>Initial determination — Inside a building</i>	
Damage, loss of shielding or spill involving a potentially dangerous source	Affected and adjacent areas (including floors above and below)
Fire or other event involving a potentially dangerous source that can spread radioactive material throughout the building (e.g. through the ventilation system)	Entire building and appropriate outside distance as indicated above
<i>Expansion based on radiological monitoring</i>	
OIL1 and OIL2 from Table 9	Wherever these levels are measured

**Table 9: Recommended OILs for field survey measurements**

OIL	OIL value	Response action (as appropriate) if the OIL is exceeded
<i>Environmental measurements</i>		
OIL 1	Gamma ( $\gamma$ ) 1000 $\mu$ Sv/h at 1 m from surface or asource  2000 counts/s direct beta( $\beta$ ) surface contamination measurement <sup>e</sup>  50counts/s direct alpha ( $\alpha$ )surfacecontaminationmeasurement <sup>f</sup>	<ul style="list-style-type: none"> <li>– Immediately evacuate or provide substantial shelter<sup>a</sup></li> <li>– Provide for decontamination of evacuees</li> <li>– Reduce inadvertent ingestion<sup>c</sup></li> <li>– Stop consumption of local produced, rainwater and milkfrom animals grazing in the area</li> <li>– Register and provide for a medical examination ofevacuees</li> <li>– If a person has handled a source with a dose rate equalto or exceeding 1000<math>\mu</math>Sv/h at 1 m<sup>e</sup>, provide animmediate medical examination</li> </ul>
OIL 2	Gamma ( $\gamma$ ) 100 $\mu$ Sv/h at 1 m from surface or asource  200 counts/s direct beta( $\beta$ ) surface contamination measurement <sup>f</sup>  10counts/s direct alpha ( $\alpha$ )surfacecontaminationmeasurement <sup>f</sup>	<ul style="list-style-type: none"> <li>– Stop consumption of local produce<sup>d</sup>, rainwater and milk from animals grazing in the area until they have been screened and contamination levels have been assessedusing OIL5 and OIL6</li> <li>– Temporarily relocate those living in the area; before relocation, reduce inadvertent ingestion<sup>c</sup>; register and estimate the dose to those who were in the area to determine if medical screening is warranted; relocation of people from the areas with the highest potential exposure should begin within days</li> <li>– If a person has handled a source with a dose rate equal to or exceeding 100 <math>\mu</math>Sv/h at 1 me, provide medical examination and evaluation; any pregnant women who have handled such a source should receive immediatemedical evaluation and dose assessment</li> </ul>
OIL 3	Gamma ( $\gamma$ ) 1 $\mu$ Sv/h at 1 mfrom surface  20 counts/s direct beta ( $\beta$ )surface contaminationmeasurement <sup>f,i</sup>  2 counts/s direct alpha ( $\alpha$ )surface contaminationmeasurement <sup>f,i</sup>	<ul style="list-style-type: none"> <li>– Stop consumption of non-essential<sup>g</sup> local produced, rainwater and milk from animals<sup>h</sup> grazing in the area until it has been screened and contamination levels havebeen assessed using OIL5 and OIL6</li> <li>– Screen local produce, rainwater and milk from animals<sup>h</sup> grazing in the area out to at least 10 times the distance to which OIL3 is exceeded and assess samples</li> </ul>

		using OIL5 and OIL6 – Consider providing iodine thyroid blocking <sup>j</sup> for fresh fission products <sup>k</sup> and for iodine contamination if replacement for essential <sup>g</sup> local produce or milk is not immediately available – Estimate the dose of those who may have consumed food, milk or rainwater from the area where restrictions were implemented to determine if medical screening is warranted
OIL 4	Gamma ( $\gamma$ ) 1 $\mu$ Sv/h at 10 cm from the skin  1000 counts/s direct beta ( $\beta$ ) skin contamination measurement <sup>f</sup>  50 counts/s direct alpha ( $\alpha$ ) skin contamination measurement <sup>f</sup>	– Provide for skin decontamination <sup>b</sup> and reduce inadvertent ingestion <sup>c</sup> – Register and provide for a medical examination

<sup>a</sup>Inside closed halls of large multi-storey buildings or large masonry structures and away from walls or windows

<sup>c</sup>Advise evacuees not to drink, eat or smoke and to keep hands away from the mouth until hands are washed.

<sup>d</sup>Local produce is food that is grown in open spaces that may be directly contaminated by the release and that is consumed within weeks (e.g. vegetables).

<sup>e</sup>This external dose rate criterion applies only to sealed dangerous sources and does not need to be revised in an emergency.

<sup>f</sup>Performed using good contamination monitoring practice.

<sup>g</sup>Restricting essential foods could result in severe health effects (e.g. severe malnutrition), and therefore essential foods should be restricted only if replacement food is available.

<sup>h</sup>Use 10% of OIL3 for milk from small animals (e.g. goats) grazing in the area.

<sup>i</sup>Deposition by rain of short lived naturally occurring radon progeny can result in count rates of four or more times the background count rate. These rates should not be confused with the deposition rates due to the emergency. Count rates due to radon progeny will decrease rapidly after the rain stops and should be back to typical background levels within a few.

<sup>j</sup>Only for several days and only if replacement food is not available.

**Table 10: Default screening oils for food, milk and water concentrations from laboratory analysis**

OIL	OIL value	Response action if the OIL is exceeded
OIL 5	Gross beta ( $\beta$ ): 100 Bq/kg or Gross alpha ( $\alpha$ ): 5 Bq/kg	Above OIL5: Assess using OIL6 Below OIL5: Safe for consumption during the emergency phase

**Table11: Default radionuclide specific OILs for food, milk and water concentrations from laboratory analysis**

Radionuclide	OIL 6 (Bq/kg)
Cs-137	2000
Sr-90	200
I-131	3000

For other radionuclides the specific OIL values are given in the IAEA publication "Safety Standards No. GSG-2: Criteria for Use in Preparedness and Response for a Nuclear or Radiological Emergency," in table 10 on pages 41 to 49.

**Table12: Guidance values for restricting exposure of emergency workers**

Tasks	Guidance value <sup>a</sup>
Life saving actions	$H_p(10) < 500$ mSv This value may be exceeded under circumstances in which the expected benefits to others clearly outweigh the emergency worker's own health risks, and the emergency worker volunteers to take the action and understands and accepts this health risk
Actions to prevent severe deterministic effects and actions to prevent the development of catastrophic conditions that could significantly affect people and the environment	$H_p(10) < 500$ mSv
Actions to avert a large collective dose	$H_p(10) < 100$ mSv

<sup>a</sup>These values apply only for the dose from exposure to external penetrating radiation. Doses from exposure to non-penetrating external radiation and from intake or skin contamination need to be prevented by all possible means. If this is not feasible, the effective dose and the equivalent dose to an organ that are received have to be limited to minimize the health risk to the individual in line with the risk associated with the guidance values given here.

## **ANNEX 5. Methodology of measurement and estimation of exposure**

### **5.1. Measurements and estimation of exposure from professionally exposed persons**

#### **5.1.1. Diagnostic radiology**

- Exposure of exposed workers that work with diagnostic x-ray devices is estimated for radiographic and fluoroscopic conditions used in most diagnostic procedures.
- During the measurements exposure time must be synchronized with the response time of the measuring instrument.
- Use of phantoms with following dimensions (height x length x width) and composition is required:
  - For diagnostic procedures: water or Plexiglas phantom with dimensions 20 cm x 30 cm x 30 cm,
  - For mammography: Plexiglas phantom with dimensions 4,5 cm x 24 cm x 18 cm,
  - For dental radiography: cylindrical water phantom with 5 liters in volume and diameter of 15 cm,
  - For computed radiography: Plexiglas phantom in cylindrical shape with diameter of 32 cm and length of 16 cm.
- Exposure estimation of exposed workers is based on the measurements of absorbed dose or absorbed dose rate in air at the spot where they work (head, chest, gonads and hands), and it is done for radiographic and fluoroscopic conditions of the mostly used diagnostic examinations.
- Exposure estimation of exposed workers and others who are in the neighboring rooms, patients in the waiting and changing rooms is performed in working conditions of the mostly used diagnostic examinations, at the distance of one meter from the surface of the wall, doors, or windows.
- Value of absorbed dose at the workplace is determined using conducted measurements and number of diagnostic procedures performed by the professionally exposed persons in one year. Obtained value is compared with corresponding data of individual monitoring.

#### **5.1.2 Nuclear medicine**

Exposure estimation of professionally exposed persons in nuclear medicine is performed using measurement results of the contamination level and the level of external exposure, taking into account dose rate and time of exposure. Obtained value for the annual effective dose is compared with corresponding individual monitoring records.

#### **5.1.3 Radiotherapy**

Estimation of the exposure of exposed workers in radiotherapy is based on the results of external exposure level measurements in the workplace for all tasks, at locations where worker is most exposed, taking into account dose rate and duration of exposure. The obtained value for annual effective dose is compared with corresponding individual monitoring records.

#### **5.1.4 Industrial radiography**

Estimation of the exposure of exposed workers is based on:

- Dose rate measurements at locations where workers can dwell during the radiography,

under the conditions of average activity of radionuclide or average anode voltage and current values of industrial X-ray unit, for most used radiography checks.

- Occupancy factor for mentioned locations
- The obtained results are compared with corresponding individual monitoring records.

### **5.1.5 Other non-medical use of sources**

- Estimation of the exposure for workers who use sealed sources in industry, agriculture, mining, geology, research, education and other non-medical practices is based on:
  - Dose rate measurements at locations where workers can remain during the equipment operation, under open and closed beam conditions.
  - Occupancy factor for mentioned locations
  - The obtained results are compared with corresponding individual monitoring records.

## **5.2 Measurements and estimation of dose for members of public**

### **5.2.1 Lightning rods with embedded radionuclide, smoke detectors with radioactive source**

Estimation of the exposure for members of public from lightning rods with embedded radionuclide and smoke detectors with radioactive source is based on:

- Dose rate measurements in the vicinity of mentioned devices at locations where members of public can remain

Occup