

---

**DEPARTMENT OF MINERALS AND ENERGY  
DEPARTEMENT VAN MINERALE EN ENERGIE**

**No. R. 388**

**28 April 2006**

NATIONAL NUCLEAR REGULATOR ACT, 1999 (ACT NO. 47 OF 1999)

**REGULATIONS IN TERMS OF SECTION 36, READ WITH SECTION 47 OF  
THE NATIONAL NUCLEAR REGULATOR ACT, 1999 (ACT NO. 47 OF 1999),  
ON SAFETY STANDARDS AND REGULATORY PRACTICES**

Under section 36, read with section 47 of the National Nuclear Regulator Act, 1999 (Act No. 47 of 1999), I B. L. Hendricks, Minister of Minerals and Energy, on the recommendation of the Board of Directors of the National Nuclear Regulator, hereby make the regulations in the Schedule.

**B L HENDRICKS  
MINISTER OF MINERALS AND ENERGY**

**SCHEDULE****CONTENTS***Sections*

1.	Definitions	3
2.	<i>Exclusion, exemption, registration</i> , licensing and <i>clearance</i>	8
3.	Principal <i>radiation protection</i> and <i>nuclear safety</i> requirements	10
4.	Requirements applicable to regulated <i>actions</i>	13
5.	<i>Decommissioning</i>	18
6.	Accidents, incidents and emergencies	20
7.	General	21

*Annexures*

1.	Exempt <i>radioactivity</i> concentrations and exempt total <i>radioactivity</i> content	22
2.	<i>Dose limits</i>	30
3.	Probabilistic <i>risk</i> limits	32

Section 1*Definitions*1. *Terms defined in the Act*

in these regulations, any word or expression to which a meaning has been assigned in the *Act*, shall have the meaning so assigned.

2. *Terms not defined in the Act*

In these regulations, unless the context indicates otherwise:

- (i) “*absorbed dose*” means the fundamental dosimetric quantity  $D$  expressed in the unit  $J \cdot kg^{-1}$ , termed the gray (Gy), defined as:

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

where  $d\bar{\epsilon}$  is the mean energy imparted by ionizing *radiation* to matter in a volume element and  $dm$  is the mass of matter in the volume element;

- (ii) “*assessment*” means the process, and the result, of analysing systematically the hazards associated with *sources* and *actions*, and associated protection and safety measures, aimed at quantifying performance measures for comparison with criteria;
- (iii) “*authorised*” means permitted in writing by the *Regulator*;
- (iv) “*authorised action*” means an *action authorised* in terms of the National Nuclear Regulator Act, 1999 (Act No. 47 of 1999);
- (v) “*average member of the critical group*” means the individual receiving the average *effective dose* or *equivalent dose* (as applicable) in the *critical group*;
- (vi) “*becquerel*” (Bq) means the unit of *radioactivity* in nuclear transformations (or disintegrations) per second;
- (vii) “*clearance*” means removal of *radioactive materials* or radioactive objects within *actions authorised* by a *nuclear installation licence*, *nuclear vessel licence* or *certificate of registration* from any further control by the *Regulator*;
- (viii) “*collective dose*” means an expression for the total *radiation dose* incurred by a population, defined as the product of the number of individuals exposed to a *source* and their average *radiation dose*. The *collective dose* is expressed in person-sievert (person.Sv) (see *collective effective dose*);
- (ix) “*collective effective dose*” means the total *effective dose* incurred by a population, being the sum of all the individual *effective doses* to members of the population. Mathematically, the total *effective dose* to a population,  $S$ , is calculated as:

$$i. S = \sum_i E_i \cdot N_i$$

where  $E_i$  is the average *effective dose* in the population subgroup  $i$  and  $N_i$  is the number of individuals in the subgroup. It can also be defined by the integral:

$$\text{ii. } S = \int E \frac{dN}{dE} dE$$

where  $\frac{dN}{dE} dE$  is the number of individuals receiving an *effective dose* between  $E$  and  $E+dE$ .

The *collective effective dose*  $S_k$  committed by an event, a decision or a finite portion of an action  $k$ , during a time interval  $T$ , is given by:

$S_k = \int_0^T \dot{S}_k(t) dt$  where  $\dot{S}_k(t)$  is the *collective effective dose rate* at time  $t$  caused by  $k$ ;

(x) “**committed equivalent dose**” means the quantity  $H_T(\tau)$ , defined as:

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

where  $t_0$  is the time of *intake*,  $\dot{H}_T(t)$  is the *equivalent dose rate* at time  $t$  in organ or tissue  $T$  and  $\tau$  is the time elapsed after an *intake* of radioactive substances. When  $\tau$  is not specified, it will be taken to be 50 years for adults and to age 70 years for *intakes* by children;

- (xi) “**critical group**” means a group of members of the public which is reasonably homogeneous with respect to its *exposure* for a given *radiation source* and given *exposure pathway* and is typical of individuals receiving the highest *effective dose* or *equivalent dose* (as applicable) by the given *exposure pathway* from the given *source*;
- (xii) “**decommissioning**” means administrative and technical actions taken to allow the removal of all of the regulatory controls from a facility (except for a repository which is closed and not decommissioned);
- (xiii) “**defence in depth**” means the application of more than a single protective measure for a given *radiation* or *nuclear safety* objective, so that the objective is achieved even if one of the protective measures fails;
- (xiv) “**discharge**” means a planned and controlled release of *radioactive nuclides* to the environment;
- (xv) “**disposal**” means the emplacement of *radioactive waste* in an approved, specified facility without the intention of retrieval and “*dispose of*” has the corresponding meaning;
- (xvi) “**dose**” means the amount of *radiation* received, where the use of a more specific term such as “*effective dose*” or “*equivalent dose*” is not necessary for defining the quantity of interest;
- (xvii) “**dose constraint**” means a prospective and source-related restriction on the individual *dose* arising from the predicted operation of the *authorised action* which serves exclusively as a bound on the optimisation of *radiation protection* and *nuclear safety*;

- (a) to limit the range of options considered in the optimisation process, and  
 (b) to restrict the *doses* via all *exposure pathways* to the *average member of the critical group*, in order to ensure that the sum of the *doses* received by that individual from all controlled *sources* remains within the *dose limit*, and which, if found retrospectively to have been exceeded, should not be regarded as an infringement of regulatory requirements but rather as a call for the *reassessment* of the optimisation of *radiation* protection.
- (xviii) “*dose limit*” means the value of *effective dose* or *equivalent dose* to individuals from *actions authorised* by a *nuclear installation licence, nuclear vessel licence* or *certificate of registration*, that must not be exceeded;
- (xix) “*effective dose*” means the quantity  $E$  expressed in the unit  $J \cdot kg^{-1}$ , termed the sievert (Sv), defined as the summation of the tissue *equivalent doses*, each multiplied by the appropriate *tissue weighting factor*:

$$i. E = \sum_T w_T \cdot H_T$$

where  $H_T$  is the *equivalent dose* in tissue  $T$  and  $w_T$  is the *tissue weighting factor* for tissue  $T$ ; from the definition of *equivalent dose*, it follows that:

$$ii. E = \sum_T w_T \cdot \sum_R w_R \cdot D_{T,R}$$

where  $w_R$  is the *radiation weighting factor* for *radiation*  $R$  and  $D_{T,R}$  is the average *absorbed dose* in the organ or tissue  $T$ ;

- (xx) “*emergency planning*” means the process of developing and maintaining the capability to take actions that will mitigate the impact of an emergency on persons, property or the environment;
- (xxi) “*emergency preparedness*” means the capability to promptly take actions that will effectively mitigate the impact of an emergency on persons, property or the environment;
- (xxii) “*emergency response*” means the performance of actions to mitigate the impact of an emergency on persons, property or the environment;
- (xxiii) “*equivalent dose*” means the quantity  $H_{T,R}$  expressed in the unit  $J \cdot kg^{-1}$ , termed the sievert (Sv), defined as:

$$1. H_{T,R} = D_{T,R} \cdot w_R$$

where  $D_{T,R}$  is the *absorbed dose* delivered by *radiation* type  $R$  averaged over a tissue or organ  $T$  and  $w_R$  is the *radiation weighting factor* for *radiation* type  $R$ ; when the *radiation* field is composed of different *radiation* types with different values of  $w_R$ , the *equivalent dose* is:

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

- (xxiv) “*environmental monitoring*” means the measurement of external *dose* rates due to *sources* in the environment and of *radioactive nuclide* concentrations in environmental media;
- (xxv) “*exclusion*” means *exclusion from* the scope of regulatory *control*;

- (xxvi) “**exemption**” means the determination by the *regulator* that an *action* need not be subject to some or all aspects of regulatory control on the basis that the exposure (or potential exposure) due to the *action* is too small to warrant the application of those aspects;
- (xxvii) “**exposure**” means the act or condition of being subject to irradiation;
- (xxviii) “**exposure pathway**” means a route by which *radioactive material* can reach or irradiate humans;
- (xxix) “**fertile**” means nuclear material which can be converted into material which is capable of nuclear fission;
- (xxx) “**fissile**” means material that undergo fission by neutrons of all energies;
- (xxxi) “**IAEA**” means the International Atomic Energy Agency;
- (xxxii) “**individual monitoring**” means *monitoring* using measurements by equipment worn **by** individual workers, or measurements of quantities of *radioactive materials* in or on their bodies;
- (xxxiii) “**institutional control**” means control of a waste *site* (for example, *disposal site*) **by a** statutory authority or institution; this control may be active (*monitoring*, surveillance, remedial work) or passive (land use control) and may be a factor in the design of a nuclear facility (for example, near surface *disposal facility*);
- (xxxiv) “**intake**” means the process of taking *radioactive nuclides* into the body by inhalation or ingestion or through the skin;
- (xxxv) “**monitoring**” means the continuous or periodic measurement of radiological and other parameters **or** determination of the status of a system;
- (xxxvi) “**normal operational exposure**” means an *exposure* which is expected to be received under normal operating conditions, including possible minor mishaps that can be kept under control;
- (xxxvii) “**nuclear safety**” means the achievement of safe operating conditions, prevention of *nuclear accidents* or mitigation of *nuclear accident* consequences, resulting in the protection of workers, the public and the environment against the potential harmful effects of ionizing radiation or *radioactive material*;
- (xxxviii) “**occupational exposure**” means *exposure* of a worker in the course of his or her work in excess of an annual *effective dose* of 1 mSv in addition to natural background *radiation*, and “occupationally exposed” has the corresponding meaning;
- (xxxix) “**operational safety assessment**” means a *safety assessment* undertaken during operations;
- (xl) “**prior safety assessment**” means a *safety assessment* undertaken prior to commencement of operations;
- (xli) “**radiation**” means *ionising radiation*;
- (xlii) “**radiation protection**” means the protection of people from the effects of *exposure* to *ionising radiation*, and the means for achieving this;
- (xliii) “**radiation weighting factor**” means a multiplier of *absorbed dose* used for *radiation protection* purposes to account for the relative effectiveness of different types of *radiation* in inducing health effects, the value of which is that specified in

the *IAEA International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources*;

- (xlv) “**radioactive waste**” means any material, whatever its physical form, remaining from an *action* requiring a *nuclear installation licence, nuclear vessel licence* or *certificate of registration* and for which no further use is foreseen, and that contains or is contaminated with *radioactive material* and does not comply with the requirements for *clearance*;
- (xlv) “**radioactive waste acceptance criteria**” means the quantitative or qualitative criteria, specified by the operator and approved by the *regulator*, for *radioactive waste* to be accepted by the operator of a repository for disposal, or by the operator of a storage facility for storage;
- (xlv) “**radon**” means the isotope  $^{222}\text{Rn}$  of the element of atomic number 86;
- (xlvii) “**registration**” means the granting of a *certificate of registration*;
- (xlviii) “**risk**” means (qualitatively expressed) the probability of a specified health effect occurring in a person or group as a result of *exposure to radiation* or (quantitatively expressed) a multiattribute quantity expressing hazard, danger or chance of harmful or injurious consequences associated with actual or potential *exposures* relating to quantities such as the probability that specific deleterious consequences may arise and the magnitude and character of such consequences;
- (xlix) “**risk assessment**” means an *assessment* of the radiological risks associated with normal operation and potential accidents involving a source or *action*;
- (l) “**safety assessment**” means an analysis to evaluate *the* performance of an overall system and its impact, where the performance measure is radiological impact or some other global measure of impact on safety;
- (li) “**safety culture**” means the assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, protection and safety issues receive the attention warranted by their significance;
- (lii) “**source**” means anything that may cause *radiation exposure*, such as by emitting *ionising radiation* or releasing radioactive substances or materials; a complex or multiple installation situated at one location or *site* may, as appropriate, be considered as a single *source* for the purposes of application of these regulations;
- (liii) “**storage**” means the holding of spent (used) nuclear fuel or *radioactive waste* in a facility that provides for its containment, with the intention of retrieval;
- (liv) “**the Act**” means the National Nuclear Regulator Act, 1999 (Act No. 47 of 1999);
- (lv) “**tissue weighting factor**” means a multiplier of the *equivalent dose* to an organ or tissue used for *radiation protection* purposes to account for the different sensitivities of different organs and tissues to the induction of stochastic effects of *radiation*, the value of which is that specified in the *IAEA International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources*;
- (lvi) “**workplace monitoring**” means *monitoring* using measurements made in the working environment.

## **Section 2**

### ***Exclusion, exemption, registration, licensing and clearance***

#### **2.1 Exclusion**

##### **2.1.1 Exclusion of actions**

In terms of the provisions of section 2 (2) (b) of the Act, the Act does not apply where,

**2.1.1.1** the level of *radioactivity* concentration of each *radioactive nuclide* in materials is below –

- (a) 0.2 Bq per gram for artificial *radioactive nuclides*;
- (b) 0.5 Bq per gram for naturally occurring *radioactive nuclides* of uranium and thorium and their progeny except for *radon*;
- (c) 10 Bq per gram for potassium-40 in materials that are used in building construction or *disposed of*;
- (d) 50 Bq per gram for potassium-40 in all other materials; or

**2.1.1.2** the level of total *radioactivity* content is below 1000Bq.

**2.1.2** Where the provisions of the Act apply to an *action* but the *Regulator* is of the opinion that such *action* is not amenable to regulatory control, the Board must advise the Minister on –

- (a) the publication of a notice determining the *action* as not amenable to regulatory control; and
- (b) appropriate steps which can be taken by the relevant level of Government or any person or body.

#### **2.2 Exemption**

##### **2.2.1 Principles**

The general principles for the issue of a *certificate of exemption* as contemplated in section 22 (3) (b)(iii) of the Act are as follows:

**2.2.1.1** the *radiation risk* to individuals caused by the *action* concerned **must** be sufficiently low not to be of regulatory concern;

**2.2.1.2** the collective radiological impact of the *action* concerned must be sufficiently low not to warrant regulatory control in the prevailing circumstances; and

**2.2.1.3** the *action* concerned must be inherently safe, with no appreciable likelihood of scenarios that could lead to a failure to meet the criteria in 2.2.1.1 and 2.2.1.2.



## 2.2.2 Exemption without further consideration

*Actions* involving *radioactive material* will qualify for *exemption* by the *Regulator* without further consideration where the following criteria are fulfilled in all feasible situations:

**2.2.2.1** the *effective dose* expected to be incurred by any member of the public due to the *exempted action* is **10  $\mu$ Sv** per annum or less; and the *collective effective dose* committed by performing the *action* for one year is no more than 1 person-Sv; or

**2.2.2.2** an *assessment* for the optimisation of protection shows that *exemption* is the optimum option; or

**2.2.2.3** either the *radioactivity* concentration or the total *radioactivity* content of each *radioactive nuclide* in the *radioactive material* is below the levels specified in Annexure 1 and the quantity possessed or processed in a period of one year is less than one tonne; or

**2.2.2.4** the *radioactivity* in the material is associated with naturally occurring *radioactive nuclides* that are not processed for their radioactive, *fissile* or *fertile* properties, and the *effective dose* expected to be incurred by any member of the public due to the *exempted action* is less than 0.25 mSv per annum.

## 2.2.3 Exemption with further consideration

*Actions* which involve *radioactive material* which do not qualify for *exemption* without further consideration as envisaged in section 2.2.2 can be given further consideration subject to a case-by-case evaluation by the *Regulator* based on the specific *radioactivity*, the total *radioactivity* of discrete *radioactive nuclides* or on *exposure* scenarios.

## 2.2.4 Exemption for the transport of radioactive material

The exemption criteria for the transport of *radioactive material* are those provided for in the *IAEA* Regulations for the Safe Transport of *Radioactive Material*, applicable in terms of section 4.8.

## 2.3 Registration

*Actions* other than those that qualify for a *certificate of exemption*, or which require a *nuclear installation licence* or a *nuclear vessel licence*, must be subject to the process of *registration* as contemplated in sections 22 and 23 of the Act.

## 2.4 Licensing

Any *nuclear installation or* nuclear vessel must be subject to the process of licensing as contemplated in sections 21, 23 and 24 of the Act.

## 2.5 Clearance

*Radioactive materials* which fall within a *Nuclear Installation Licence, Nuclear Vessel Licence* or *Certificate of Registration* may be cleared from further compliance with the requirements of the *nuclear authorisation* provided that such materials meet the principles for *exemption* as detailed in 2.2 or that approval has been given by the *Regulator* on a case-by-case consideration.

## Section 3

### Principal radiation protection and nuclear safety requirements

The following principal *radiation protection* and *nuclear safety* requirements apply to *actions authorised* by, or seeking authorisation in terms of, a *nuclear installation licence, a nuclear vessel licence or a certificate of registration*.

#### 3.1 Dose and risk limits

3.1.1 The *dose* to an individual arising from normal operating conditions must not exceed the limits specified in Annexure 2.

3.1.2 The *risk of* fatality from any *action* as defined in *the Act* must not exceed the limits specified in Annexure 3.

#### 3.2 Optimisation of radiation protection and nuclear safety

The magnitude of doses to individuals, the number of people exposed and the likelihood of *incurring* exposures must be kept as low as reasonably achievable, economic and social factors being taken into account (ALARA).

#### 3.3 Prior safety assessment

Measures to control the *risk of nuclear damage* to individuals must be determined on the basis of a *prior safety assessment* which is suitable and sufficient to identify all significant *radiation* hazards and to evaluate the nature and expected magnitude of the associated *risks*, with due regard to the *dose* and *risk* limits in Annexures 2 and 3.

Where it can be justified that no credible accident scenarios exist, a *risk assessment* to demonstrate compliance with Annexure 3 is not required to be included as part of the *prior safety assessment*.

### 3.4 Good engineering practice

Installations, equipment or *plant* requiring a *nuclear installation licence*, a *nuclear vessel licence* or a *certificate of registration* and having an impact on *radiation* or *nuclear safety* must be designed, built and operated in accordance with good engineering practice.

### 3.5 Safety culture

A *safety culture* must be fostered and maintained to encourage a questioning and learning attitude to *radiation protection* and *nuclear safety* and to discourage complacency.

### 3.6 Retrospective application of regulations

3.6.1 Subject to 3.6.2, where compliance with the applicable requirements cannot be demonstrated for an *action* which is restricted in terms of section 20 of *the Act* and which existed before the coming into force of these regulations, the person engaged in that *action* must within two months of the coming into force of these regulations or within **two** months of the issuing of the *nuclear authorisation*, whichever is the later, submit to the *Regulator* an *action* plan to bring the *action* into compliance.

3.6.2 The requirements specified in 4.5.4 do not apply to bulk mineral residue deposits and/or facilities where deposition was discontinued prior to the date of these regulations or prior to the date of such deposits and/or facilities being *authorised* by the Regulator, whichever date is the earlier. These facilities must nevertheless still be regulated and the doses must be shown to be optimised.

### 3.7 Regulatory approval of *radiation protection* and *nuclear safety* measures

3.7.1 The holder of the *nuclear authorisation* is responsible for *radiation protection* and *nuclear safety*, including compliance with applicable requirements **such as** the preparation of the required *safety assessments*, programmes and procedures relating to the siting, design, construction, operation and *decommissioning* of facilities.

3.7.2 Situations where formal approval of *radiation protection* and *nuclear safety* measures by the *Regulator* is necessary should be limited to those where this is appropriate taking into account the nature **and** extent of the *risk* and the need for building stakeholder confidence.

### 3.8 Accident management and *emergency planning, emergency preparedness and emergency response*

Where the *prior safety assessment or operational safety assessment* has identified the reasonable possibility of a *nuclear accident*, accident prevention and mitigation measures based on the principle of *defence in depth* and which address accident management procedures including *emergency planning, emergency preparedness and emergency response* must be established, implemented and maintained. The principle of *defence in depth* must be applied **as** appropriate.

### 3.9 *Defence in depth*

**A** multilayer (*defence in depth*) system of provisions for *radiation protection and nuclear safety* commensurate with the magnitude and likelihood of the potential *exposures* involved shall **be** applied to *sources* such that a failure at one layer is compensated for or corrected by subsequent layers, for the purposes of –

- (a) preventing *nuclear accidents*;
- (b) mitigating the consequences of any such accidents; and
- (c) restoring *sources* to safe conditions after any such accident.

### 3.10 Quality management

**A** quality management programme must be established, implemented and maintained in order to ensure compliance with the conditions of the *nuclear authorisation*.

### 3.11 Application of *radiation protection and nuclear safety*

The application of the *radiation protection and nuclear safety* requirements contained in these regulations to any *action* should be commensurate with the characteristics of the *Action* and with the magnitude and likelihood of the *exposure*, as determined in the *safety assessments*. Not all the requirements are relevant to every *action*.

## **Section 4**

### **Requirements applicable to regulated actions**

Subject to 4.12, the following requirements apply to *actions authorised* by a *nuclear installation licence, nuclear vessel licence* or *certificate of registration*.

#### **4.1 Operational safety assessment**

**4.1.1** *Operational safety assessments* must be made and submitted to the *Regulator* at intervals specified in the *nuclear authorisation* and which must be commensurate with the nature of the operation and the *radiation risks* involved.

**4.1.2** *Operational safety assessments* must be of sufficient scope and must be conducted and maintained in order to demonstrate continuing compliance with the *dose, risk* limits and other relevant conditions of the *nuclear authorisation*.

**4.1.3** The *operational safety assessment* must establish the basis for all the *operational safety*-related programmes, limitations and design requirements.

#### **4.2 Controls and limitations on operation**

**4.2.1** The holder of a *nuclear authorisation* is restricted to the *actions* within the specified *site* and within any limitations imposed in the authorisation.

**4.2.2** Technical specifications must be established, implemented and maintained, where applicable, in terms of the *safety assessment*. Such operating technical specifications must provide a link between the *safety assessment* and the operation and must, as a minimum, include the following:

**4.2.2.1** operating safety limitations as imposed by the design or by the safety criteria;

**4.2.2.2** surveillance requirements to verify that equipment important to safety is operating satisfactorily or that parameters are within the safety limitations; and

**4.2.2.3** limitations on the operation, in the event that equipment important to safety becomes inoperable or in the event that safety limitations are exceeded.

**4.2.3** *Radioactive waste acceptance criteria* in respect of waste *disposal or storage* facilities must be established.

**4.2.4** Operations must be conducted in accordance with formal procedures as required by the conditions of the *nuclear authorisation*.

### **4.3 Maintenance and inspection programme**

**4.3.1** An appropriate maintenance and inspection programme must be established.

**4.3.2** The maintenance and inspection programme must be implemented to ensure that the reliability and integrity of installations, equipment and *plant* having an impact on *radiation and nuclear safety* are commensurate with the *dose limits* and *risk* limits in Annexures 2 and 3.

### **4.4 Staffing and qualification**

**4.4.1** An adequate number of competent, qualified and trained staff must be responsible for carrying out the functions associated with *radiation protection* and *nuclear safety* and for maintaining an appropriate *safety culture*.

**4.4.2** The appropriate staff must be consulted on all decisions, that may impact on *radiation protection* and *nuclear safety*.

### **4.5 Radiation protection**

#### **4.5.1 Optimisation of protection**

Measures commensurate with the magnitude and likelihood of *exposure* must be implemented to ensure that *exposures* associated with the *authorised action* are kept as low as reasonably achievable, economic and social factors being taken into account (ALARA).

#### **4.5.2 Dose constraints**

**4.5.2.1** Where applicable in terms of the *prior safety assessment*, the optimisation of *radiation protection* must be subject to *dose constraints* specific to the *authorised action*, which must not exceed values that can cause the relevant *dose limits* to be exceeded and which will ensure as far as practicable that *doses* are restricted by application of the ALARA principle on a source-specific basis rather than by *dose limits*.

**4.5.2.2** For members of the public, the *dose constraint* applicable to the *average member of the critical group* within the exposed population is 0,25 mSv per year specific to the *authorised action* unless otherwise agreed by the *Regulator* on a case-by-case basis, taking into account the *dose limit* specified in Annexure 2 for *exposure* of members of the public from all *sources*.

### **4.5.3 Annual authorised discharge quantity**

The *Regulator* may, for the purposes of controlling radioactive *discharges* from a single *authorised action*, determine a *source-specific annual authorised discharge quantity* in the *nuclear authorisation*, which must take into account the *dose constraint* contemplated in section 4.5.2.2.

### **4.5.4 Radiation dose limitation**

The *normal operational exposure of* individuals must be restricted to ensure that neither the *effective dose* nor the *equivalent dose* to relevant organs or tissues, caused by the possible combination of *authorised actions*, exceeds any relevant *dose limit* specified in Annexure 2. In order to comply with these regulations holders *of nuclear authorisations must*, as a precondition for engagement of occupationally exposed workers who are not their employees, obtain from the employers, including self employed individuals, the previous *occupational exposure* history of such workers.

### **4.5.5 Medical Surveillance and Health Register**

**4.5.5.1** A comprehensive medical surveillance programme and health register must be established and maintained for all occupationally exposed workers in a form approved by the NNR. **All** entries in the health register must be made by an appointed medical practitioner or a person so authorized in writing. The holder must retain the register for a period of **40** years from the date of last entry.

**4.5.5.2** An employee must have right of access *to* his medical records and health register at all times.

**4.5.5.3** After consent has been obtained from the employee, the holder must provide the NNR with access to the employee's medical records and health register. The NNR may, with the consent of the employee, appoint an independent medical practitioner to assist in the conduct of a review of said records.

### **4.5.6 Dose register**

**A** *dose register of* every occupationally exposed worker must be established and maintained.

#### 4.6 *Radioactive waste* management

**4.6.1** A *radioactive waste* management programme must be established, implemented and maintained in order to –

**4.6.1.1** ensure waste generation control;

**4.6.1.2** ensure the identification, quantification, characterisation and classification of any *radioactive waste* generated;

**4.6.1.3** provide for the necessary treatment and other waste management steps leading to safe clearance, or *authorised discharge, disposal, reuse or recycling*; and

**4.6.1.4** provide for the safe storage of *radioactive waste* between any waste management processes.

**4.6.2** The safety of long-term *radioactive waste* storage options must be assured for the envisaged period of storage.

**4.6.3** *Radioactive material*, radioactively contaminated material or radioactive waste may be removed from further compliance with the conditions of the *nuclear authorisation* if such material is transported to the *site* of any other *authorised action* or complies with the requirements for –

**4.6.3.1** an *authorised discharge*; or

**4.6.3.2** *authorised recycling or authorised reuse*; or

**4.6.3.3** *clearance*; or

**4.6.3.4** the material is transported directly to an *authorised* waste storage or *disposal* facility and complies with the applicable waste acceptance criteria.

#### 4.7 *Environmental monitoring and surveillance*

An appropriate *environmental monitoring* and surveillance programme must be established, implemented and maintained to verify that the *storage, disposal* or effluent *discharge* of *radioactive waste* complies with the conditions of the *nuclear authorisation*.



#### 4.8 Transport of *radioactive material*

Transport of *radioactive material* or of any equipment or objects contaminated with *radioactive material* off the *site* or on roads which are accessible to the public must *be* carried out in terms of the provisions of the *IAEA* Regulations for The Safe Transport of *Radioactive Material*, in the revision specified in the *nuclear authorisation*.

#### 4.9 Physical security

Physical security arrangements must be established, implemented and maintained in order to demonstrate that all necessary measures are taken to prevent, as *far* as is reasonable, unauthorised access to *sites* or diversion, theft or removal of *radioactive material* that does not meet the requirements for *clearance* in terms of section 2.5.

#### 4.10 Records and reports

**4.10.1** A system of record keeping for all records specified in the *nuclear authorisation* must be established, implemented and maintained.

**4.10.2** Operational reports must be submitted to the *Regulator* at predetermined periods as specified in the *nuclear authorisation* and must contain such information as the *Regulator* may require on the basis of the *safety assessments*.

**4.10.3** A reporting mechanism must be established, implemented and maintained for *nuclear incidents* and *nuclear accidents* or any other events that the *Regulator* may specify in the authorisation.

#### 4.11 Monitoring of workers

**4.11.1** in workplaces where workers are liable to receive *doses* exceeding three tenths of the applicable *dose limits* in section 1.1.1 of Annexure 2, as identified by the *prior safety assessment* and confirmed by subsequent *operational safety assessments*, *individual monitoring* of workers must be undertaken where appropriate, adequate and feasible.

**4.11.2** For workers in the workplaces contemplated in section 4.11.1 for whom *individual monitoring* is inappropriate, inadequate or not feasible, the *occupational exposure* of such workers must be assessed from the results of *workplace monitoring* and information on the locations and durations of the workers.

**4.11.3** In workplaces where occupationally exposed workers are unlikely to receive *doses* exceeding three tenths of the applicable *dose limits* in section 1.1.1 of Annexure 2, *workplace monitoring* must be implemented to keep under review the workplace *exposure* conditions, in order to maintain an awareness of any

significant changes in conditions and to enable *doses* to be assigned to occupationally exposed workers on the basis of general workplace *exposure* conditions.

#### **4.12 Application to radon exposure**

For *actions* where the *prior safety assessment* contemplated in section 3.3, or the subsequent *workplace monitoring* contemplated in section 4.1.1.3, demonstrates that the *occupational exposure* to radon does not exceed an action level of 6 mSv/a, the requirements of section 4 applicable to *occupational exposure* to radon shall be limited to those of sections 4.4, 4.5.5, 4.5.6, 4.10 and 4.1.1.3.

### **Section 5**

#### *Decommissioning*

The following requirements apply to *actions* authorised by a nuclear installation licence, nuclear vessel licence or certificate of registration which involves the decommissioning of any installation, plant or equipment having an impact on radiation protection and nuclear safety, or the release of radioactively contaminated land for other uses.

#### **5.1 Decommissioning strategy and planning**

**5.1.1** A decommissioning strategy must be submitted as part of the *prior safety assessment* and must be updated throughout the operation of the *authorised action* as a basis for detailed *decommissioning* planning.

**5.1.2** A decommissioning plan must be submitted to the *Regulator* as a basis for authorisation of specific *actions* or phases of *decommissioning*.

**5.1.3** The *decommissioning plan* must specify any *institutional controls* that are required to maintain radiation safety after termination of the *period of responsibility* of the holder of the *nuclear authorisation* and must minimise as far as reasonable the need for such *institutional controls*.

#### **5.2 Availability of resources**

It must be demonstrated to the *Regulator* that sufficient *resources* will be available from the time of cessation of the operation to the termination of the *period of responsibility*.

### 5.3 Requirements for *decommissioning* operations

All *decommissioning* operations must be conducted in compliance with the applicable requirements of section 4.

### 5.4 Release of radioactively contaminated land

**5.4.1** A *site* used in the conduct of an *authorized action* may be released for unrestricted use provided that it is demonstrated—

**5.4.1.1** that radioactive contamination and *radioactive materials* which can reasonably be attributed to the authorized *action* have been removed from the *site* or, in the case of naturally occurring *radioactive nuclides*, have activity concentrations *below* the **levels for exclusion** specified in section 2.1.1.1 (b), (c) and (d); or

**5.4.1.2** where the provisions in section 5.4.1.1 cannot reasonably be achieved, remedial measures have been implemented in accordance with section 4.5.1 to achieve optimization of protection constrained in accordance with section 4.5.2 such that the annual *effective dose* received by the *average member of the critical group* for all feasible future situations, arising from the residual radioactive contamination and *radioactive materials* which can reasonably be attributed to the regulated *action*, does not exceed the *dose constraint* that was applicable during the operations.

**5.4.2** In the event that the release of a *site* in accordance with the conditions in section 5.4.1.2 can only be reasonably achieved by imposing restrictions on the use of the *site*, the *Regulator* may, subject to the conditions in section 5.4.1.2 being met, approve the release of that *site* for restricted use.

### 5.5 Obligations under other statutes

Where there are obligations on the holder of the *nuclear authorisation* under other statutes with respect to *decommissioning*, the requirements under 5.1 and 5.2 may be integrated into an overall *decommissioning* strategy and funding mechanism which may serve to satisfy all relevant statutes in accordance with the co-operative governance agreements established in terms of section 6 of *the Act*.

## **Section 6**

### **Accidents, incidents and emergencies**

The provisions of this section are applicable to emergency *exposure* situations requiring protective *action* to reduce or avert temporary *exposures*.

#### **6.1 Criteria for the definition of a *nuclear accident***

Any occurrence or succession of occurrences having the same origin and resulting in an unintended/unauthorised exposure to radiation or release of *radioactive material*, which is capable of giving rise to an *effective dose* in excess of 1 mSv to the public off-*site* in a year, or in excess of 50 mSv to a worker on *site* received essentially at the time of the event, is regarded as a *nuclear accident* as defined in section 1 (xiii) of *the Act*.

#### **6.2 Criteria for the definition of a *nuclear incident***

Any unintended event which is reasonably capable of giving rise to an *effective dose* equal to or in excess of 0,1 mSv to the public off *site* received essentially at the time of the event, or the unintended spread of radioactive contamination or exposure to radiation, which could reasonably give rise to an *effective dose* in excess of 20 mSv to a worker on *site* received essentially at the time of the event, or significant failure of safety provisions, is regarded as a *nuclear incident* as defined in section 1 (xvii) of *the Act*.

#### **6.3 Information to be supplied**

The holder of a *nuclear authorisation* must immediately inform the *Regulator* when a *nuclear accident* occurs or an incident has arisen or is expected to occur or arise, as the case may be, and shall provide such information as may be required, including –

6.3.1 the current situation and its evolution;

6.3.2 measures taken to terminate the *nuclear accident* and/or incident to protect workers and members of the public; and

6.3.3 the *exposures* that have occurred and those expected to be incurred.

#### **6.4 Emergency or remedial measures**

Emergency or remedial measures must be considered in the vicinity of a *nuclear accident* where the potential exists that any member of the public may receive more than an annual *effective dose* of 1 mSv resulting from the accident.

## Section 7

### General

- 7.1** The safety standards referred to in section 1(xiii)(a) of *the Act* are the criteria for a *nuclear accident* specified in 6.1.
- 7.2** The *exclusion* levels provided for in the safety standards referred to in section 2(2)(b) of *the Act* are the *exclusion* criteria specified in 2.1.
- 7.3** The *exemption* criteria specified in the safety standards referred to in section 22(3)(b)(ii) of *the Act* are the *exemption* criteria specified in 2.2.
- 7.4** The safety standards with respect to the *risk* of *nuclear damage* referred to in section 1(xxii)(a)(iii) of *the Act* are the *risk* levels corresponding to the release criteria contained in 2.5 and 5.4 for materials and land respectively.
- 7.5** The safety standard with respect to the *risk* of *nuclear damage* referred to in section 37(2)(b) of *the Act* is the potential *dose* criterion specified in 6.4.
- 7.6** The safety standards with respect to the *risk* of *nuclear damage* referred to in section 39(2) of *the Act* are the *risk* levels corresponding to the release criteria contained in 2.5 and 5.4 for materials and land respectively.
- 7.7** The safety standards referred to in section 41(4)(e) of *the Act* are the release criteria contained in 2.5 and 5.4 for materials and land respectively.
- 7.8** The *exemption* criteria provided for in the safety standards referred to in section 41(4)(f) of *the Act* are the *exemption* criteria specified in 2.2.
- 7.9** The safety standards referred to in section 41(4)(g) of *the Act* are the release criteria contained in 2.5 and 5.4 for materials and land respectively.

## Annexure 1

**Exempt radioactivity concentrations and exempt total radioactivity content**

<i>Radioactive nuclide</i>	<i>Radioactivity Concentration (Bq/g)</i>	<i>Total Radioactivity Content (Bq)</i>
<b>H-3</b>	1 E+06	1 E+09
Be-7	1 E+03	1 E+07
C-14	1 E+04	1 E+07
O-15	1 E+02	1 E+09
F-18	1 E+01	1 E+06
Na-22	1 E+01	1 E+06
Na-24	1 E+01	1 E+05
Si-31	1 E+03	1 E+06
P-32	1 E+03	1 E+05
P-33	1 E+05	1 E+08
s-35	1 E+05	1 E+08
Cl-36	1 E+04	1 E+06
Cl-38	1 E+01	1 E+05
Ar-37	1 E+06	1 E+08
Ar-41	1 E+02	1 E+09
K-40	1 E+02	1 E+06
K-42	1 E+02	1 E+06
K-43	1 E+01	1 E+06
Ca-45	1 E+04	1 E+07
Ca-47	1 E+01	1 E+06
<b>Sc-46</b>	1 E+01	1 E+06
sc-47	1 E+02	1 E+06
Sc-48	1 E+01	1 E+05
v-48	1 E+01	1 E+05
Cr-51	1 E+03	1 E+07
<b>Mn-51</b>	1 E+01	1 E+05
Mn-52	1 E+01	1 E+05
Mn-52m	1 E+01	1 E+05
<b>Mn-53</b>	1 E+04	1 E+09
Mn-54	1 E+01	1 E+06
<b>Mn-56</b>	1 E+01	1 E+05
Fe-52	1 E+01	1 E+06
<b>Fe-55</b>	1 E+04	1 E+06
Fe-59	1 E+01	1 E+06
Co-55	1 E+01	1 E+06
CO-56	1 E+01	1 E+05
<b>Co-57</b>	1 E+02	1 E+06
CO-58	1 E+01	1 E+06
Co-58m	1 E+04	1 E+07
Co-60	1 E+01	1 E+05

<i>Radioactive nuclide</i>	<i>Radioactivity</i> Concentration (Bq/g)	Total Radioactivity Content (Bq)
Co-60m	1 E+03	1 E+06
Co-61	1 E+02	1 E+06
Co-62m	1 E+01	1 E+05
Ni-59	1 E+04	1 E+08
Ni-63	1 E+05	1 E+08
Ni-65	1 E+01	1 E+06
Cu-64	1 E+02	1 E+06
<b>Zn-65</b>	1 E+01	1 E+06
Zn-69	1 E+04	1 E+06
Zn-69m	1 E+02	1 E+06
Ga-72	1 E+01	1 E+05
Ge-71	1 E+04	1 E+08
As-73	1 E+03	1 E+07
As-74	1 E+01	1 E+06
As-76	1 E+02	1 E+05
As-77	1 E+03	1 E+06
Se-75	1 E+02	1 E+06
Br-82	1 E+01	1 E+06
Kr-74	1 E+02	1 E+09
Kr-76	1 E+02	1 E+09
Kr-77	1 E+02	1 E+09
Kr-79	1 E+03	1 E+05
<b>Kr-81</b>	1 E+04	1 E+07
Kr-83m	1 E+05	1 E+12
<b>Kr-85</b>	1 E+05	1 E+04
<b>Kr-85m</b>	1 E+03	1 E+10
Kr-87	1 E+02	1 E+09
Kr-88	1 E+02	1 E+09
Rb-86	1 E+02	1 E+05
Sr-85	1 E+02	1 E+06
Sr-85m	1 E+02	1 E+07
Sr-87m	1 E+02	1 E+06
Sr-89	1 E+03	1 E+06
Sr-90*	1 E+02	1 E+04
Sr-91	1 E+01	1 E+05
Sr-92	1 E+01	1 E+06
Y-90	1 E+03	1 E+05
Y-91	1 E+03	1 E+06
Y-91m	1 E+02	1 E+06
Y-92	1 E+02	1 E+05
Y-93	1 E+02	1 E+05
Zr-93*	1 E+03	1 E+07
Zr-95	1 E+01	1 E+06

<i>Radioactive nuclide</i>	<i>Radioactivity Concentration (Bq/g)</i>	<i>Total Radioactivity Content (Bq)</i>
<b>Zr-97*</b>	1 E+01	1 E+05
Nb-93m	1 E+04	1 E+07
<b>Nb-94</b>	1 E+01	1 E+06
<b>Nb-95</b>	1 E+01	1 E+06
Nb-97	1 E+01	1 E+06
Nb-98	1 E+01	1 E+05
<del>Mo-90</del>	1 E+01	1 E+06
<b>Mo-93</b>	1 E+03	1 E+08
<b>Mo-99</b>	1 E+02	1 E+06
Mo-101	1 E+01	1 E+06
Tc-96	1 E+01	1 E+06
<b>Tc-96m</b>	1 E+03	1 E+07
Tc-97	1 E+03	1 E+08
Tc-97m	1 E+03	1 E+07
Tc-99	1 E+04	1 E+07
Tc-99m	1 E+02	1 E+07
Ru-97	1 E+02	1 E+07
<b>Ru-103</b>	1 E+02	1 E+06
Ru-105	1 E+01	1 E+06
<b>Ru-106*</b>	1 E+02	1 E+05
Rh-103m	1 E+04	1 E+08
Rh-105	1 E+02	1 E+07
Pd-103	1 E+03	1 E+08
Pd-109	1 E+03	1 E+06
<del>Ag-105</del>	1 E+02	1 E+06
Ag-110m	1 E+01	1 E+06
Ag-111	1 E+03	1 E+06
Cd-109	1 E+04	1 E+06
Cd-115	1 E+02	1 E+06
Cd-115m	1 E+03	1 E+06
In-111	1 E+02	1 E+06
<del>In-113m</del>	1 E+02	1 E+06
<b>In-114m</b>	1 E+02	1 E+06
In-115m	1 E+02	1 E+06
Sn-113	1 E+03	1 E+07
<b>Sn-125</b>	1 E+02	1 E+05
<b>Sb-122</b>	1 E+02	1 E+04
<b>Sb-124</b>	1 E+01	1 E+06
Sb-125	1 E+02	1 E+06
Te-123m	1 E+02	1 E+07
Te-125m	1 E+03	1 E+07
Te-127	1 E+03	1 E+06
Te-127m	1 E+03	1 E+07



<i>Radioactive nuclide</i>	<i>Radioactivity Concentration (Bq/g)</i>	<i>Total Radioactivity Content (Bq)</i>
Te-129	1 E+02	1 E+06
Te-129m	1 E+03	1 E+06
Te-131	1 E+02	1 E+05
Te-131m	1 E+01	1 E+06
Te-132	1 E+02	1 E+07
Te-133	1 E+01	1 E+05
Te-133m	1 E+01	1 E+05
Te-134	1 E+01	1 E+06
I-123	1 E+02	1 E+07
I-125	1 E+03	1 E+06
I-126	1 E+02	1 E+06
<b>I-129</b>	1 E+02	1 E+05
I-130	1 E+01	1 E+06
I-131	1 E+02	1 E+06
I-132	1 E+01	1 E+05
I-133	1 E+01	1 E+06
I-134	1 E+01	1 E+05
I-135	1 E+01	1 E+06
Xe-131m	1 E+04	1 E+04
Xe-133	1 E+03	1 E+04
Xe-135	1 E+03	1 E+10
Cs-129	1 E+02	1 E+05
Cs-131	1 E+03	1 E+06
Cs-132	1 E+01	1 E+05
Cs-134m	1 E+03	1 E+05
cs-134	1 E+01	1 E+04
Cs-135	1 E+04	1 E+07
<b>Cs-136</b>	1 E+01	1 E+05
<b>Cs-137*</b>	1 E+01	1 E+04
Cs-138	1 E+01	1 E+04
Ba-131	1 E+02	1 E+06
Ba-140*	1 E+01	1 E+05
<b>La-140</b>	1 E+01	1 E+05
Ce-139	1 E+02	1 E+06
Ce-141	1 E+02	1 E+07
<b>Ce-143</b>	1 E+02	1 E+06
Ce-144*	1 E+02	1 E+05
Pr-142	1 E+02	1 E+05
Pr-143	1 E+04	1 E+06
Nd-147	1 E+02	1 E+06
<b>Nd-149</b>	1 E+02	1 E+06
Pm-147	1 E+04	1 E+07
Pm-149	1 E+03	1 E+06

<i>Radioactive nuclide</i>	<i>Radioactivity Concentration (Bq/g)</i>	<i>Total Radioactivity Content (Bq)</i>
Sm-151	1 E+04	1 E+08
Sm-153	1 E+02	1 E+06
<b>Eu-152</b>	<b>1 E+01</b>	1 E+06
Eu-152m	1 E+02	1 E+06
Eu-154	1 E+01	1 E+06
Eu-155	<b>1 E+02</b>	1 E+07
<del>Gd-153</del>	1 E+02	1 E+07
Gd-159	<b>1 E+03</b>	1 E+06
Tb-160	1 E+01	1 E+06
Dy-165	1 E+03	1 E+06
Dy-166	1 E+03	1 E+06
Ho-166	1 E+03	1 E+05
Er-169	1 E+04	1 E+07
Er-171	1 E+02	1 E+06
Tm-170	1 E+03	1 E+06
Tm-171	<b>1 E+04</b>	1 E+08
<b>Yb-175</b>	1 E+03	1 E+07
Lu-177	1 E+03	1 E+07
Hf-181	1 E+01	1 E+06
Ta-182	1 E+01	1 E+04
w-181	1 E+03	1 E+07
W-185	1 E+04	1 E+07
W-187	<b>1 E+02</b>	1 E+06
<b>Re-186</b>	1 E+03	1 E+06
<b>Re-188</b>	1 E+02	1 E+05
Os-185	<b>1 E+01</b>	1 E+06
os-191	1 E+02	1 E+07
<del>Os-191m</del>	1 E+03	1 E+07
<b>Os-193</b>	1 E+02	1 E+06
Ir-190	1 E+01	1 E+06
Ir-192	1 E+01	1 E+04
<b>Ir-194</b>	1 E+02	1 E+05
Pt-191	1 E+02	1 E+06
Pt-193m	1 E+03	1 E+07
Pt-197	1 E+03	1 E+06
Pt-197m	1 E+02	1 E+06
Au-198	1 E+02	1 E+06
Au-199	1 E+02	1 E+06
<b>Hg-197</b>	1 E+02	<b>1 E+07</b>
Hg197m	1 E+02	1 E+06
Hg-203	1 E+02	1 E+05
Tl-200	1 E+01	1 E+06
TI-201	1 E+02	1 E+06

<i>Radioactive nuclide</i>	<i>Radioactivity Concentration(Bq/g)</i>	Total <i>Radioactivity Content (Bq)</i>
TI-202	1 E+02	1 E+06
TI-204	1 E+04	1 E+04
Pb-203	1 E+02	1 E+06
Pb-210*	1 E+01	1 E+04
Pb-212*	1 E+01	1 E+05
Bi-206	1 E+01	1 E+05
Bi-207	1 E+01	1 E+06
Bi-210	1 E+03	1 E+06
Bi-212*	1 E+01	1 E+05
Po-203	1 E+01	1 E+06
Po-205	1 E+01	1 E+06
<b>Po-207</b>	1 E+01	1 E+06
Po-210	1 E+01	1 E+04
At-211	1 E+03	1 E+07
Rn-220*	1 E+04	1 E+07
Rn-222*	1 E+01	1 E+08
Ra-223*	1 E+02	1 E+05
Ra-224*	1 E+01	1 E+05
Ra-225	1 E+02	1 E+05
Ra-226*	1 E+01	1 E+04
Ra-227	1 E+02	1 E+06
Ra-228*	1 E+01	1 E+05
Ac-228	1 E+01	1 E+06
Th-226''	1 E+03	1 E+07
Th-227	1 E+01	1 E+04
Th-228*	1 E+00	1 E+04
Th-229''	1 E+00	1 E+03
Th-230	1 E+00	1 E+04
Th-231	1 E+03	1 E+07
Th-nat* (incl.Th-232)	1 E+00	1 E+03
Th-234''	1 E+03	1 E+05
Pa-230	1 E+01	1 E+06
Pa-231	1 E+00	1 E+03
Pa-233	1 E+02	1 E+07
U-230''	1 E+01	1 E+05
U-231	1 E+02	1 E+07
U-232*	1 E+00	1 E+03
U-233	1 E+01	1 E+04
U-234	1 E+01	1 E+04
U-235*	1 E+01	1 E+04
U-236	1 E+01	1 E+04
U-237	1 E+02	1 E+06
U-238*	1 E+01	1 E+04

<i>Radioactive nuclide</i>	<i>Radioactivity Concentration (Bq/g)</i>	<i>Total Radioactivity Content (Bq)</i>
U-nat*	1 E+00	1 E+03
U-239	1 E+02	1 E+06
U-240	1 E+03	1 E+07
U-240*	1 E+01	1 E+06
Np-237*	1 E+00	1 E+03
Np-239	1 E+02	1 E+07
Np-240	1 E+01	1 E+06
Pu-234	1 E+02	1 E+07
Pu-235	1 E+02	1 E+07
Pu-236	1 E+01	1 E+04
Pu-237	1 E+03	1 E+07
Pu-238	1 E+00	1 E+04
Pu-239	1 E+00	1 E+04
Pu-240	1 E+00	1 E+03
Pu-241	1 E+02	1 E+05
Pu-242	1 E+00	1 E+04
Pu-243	1 E+03	1 E+07
Pu-244	1 E+00	1 E+04
Am-241	1 E+00	1 E+04
Am-242	1 E+03	1 E+06
Am-242m*	1 E+00	1 E+04
Am-243*	1 E+00	1 E+03
Cm-242	1 E+02	1 E+05
Cm-243	1 E+00	1 E+04
Cm-244	1 E+01	1 E+04
Cm-245	1 E+00	1 E+03
Cm-246	1 E+00	1 E+03
Cm-247	1 E+00	1 E+04
Cm-248	1 E+00	1 E+03
Bk-249	1 E+03	1 E+06
Cf-246	1 E+03	1 E+06
Cf-248	1 E+01	1 E+04
Cf-249	1 E+00	1 E+03
Cf-250	1 E+01	1 E+04
Cf-251	1 E+00	1 E+03
Cf-252	1 E+01	1 E+04
Cf-253	1 E+02	1 E+05
Cf-254	1 E+00	1 E+03
Es-253	1 E+02	1 E+05
Es-254	1 E+01	1 E+04
Es-254m	1 E+02	1 E+06
Fm-254	1 E+04	1 E+07
Fm-255	1 E+03	1 E+06