United Arab Emirates

FANR
الهيئة الاتحادية للرقابة النووية
Federal Authority for Nuclear Regulation

Regulation

Basic Safety Standards for Facilities and Activities involving Ionizing Radiation other than in Nuclear Facilities

(FANR-REG-24)

Version 1

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Contents

Definitions

Article (1)

For purposes of this regulation, the following terms shall have the meanings set forth below. Other capitalised terms used but not defined herein shall have the meaning ascribed to them in Article 1 of the Federal Law by Decree No. 6 of 2009 Concerning the Peaceful Uses of Nuclear Energy (the Law):

Absorbed Dose	The fundamental dosimetric quantity D, defined as $$D = \frac{d\bar{E}}{dm}$$ Where $d\bar{E}$ is the mean energy imparted by ionizing radiation to matter in a volume element and d*m* is the mass of matter in the volume element.
Activity Concentration	The radioactivity per unit mass of a material in which the radionuclides are essentially uniformly distributed.
Clearance	Removal of Radioactive Material or radioactive objects within authorised practices from any further Regulatory Control by the Authority.
Covered Activities	Any Regulated Activity specified or encompassed within those described in Article 2(1) of this regulation.
Diagnostic Reference Level(s)	A level used in medical imaging to indicate whether, in routine conditions, the Dose to the patient or the quantity of Radioactive Material administered in a specified radiological procedure is unusually high or low for that procedure. Diagnostic Reference Levels are established following consultation with health competent authorities and relevant professional bodies and are based upon surveys or published values appropriate to the circumstances in the State.

Dose Constraint

A prospective and source-related restriction on the individual Dose from a Radiation Source, which provides a basic level of protection for the most highly exposed individuals from a Radiation Source, and serves as an upper bound on the Dose in Optimisation of protection for that Radiation Source. For Occupational Exposures, the Dose Constraint is a value of individual Dose used to limit the range of options considered in the process of Optimisation. For Public Exposure, the Dose Constraint is an upper bound on the annual Doses that members of the public should receive from the planned Operation of any controlled Radiation Source.

Effective Dose

The quantity E defined as a summation of the tissue Equivalent Doses, which is each multiplied by the appropriate tissue weighting factor where H_T is the Equivalent Dose in tissue T and w_T is the Tissue Weighting Factor for tissue T .

$$E = \sum_T w_T . H_T$$

From the definition of Equivalent Dose, it follows that 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.

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

Equivalent Dose

The quantity $H_{T,R}$, defined as 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:

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

When the radiation field is composed of different radiation types with different values of w_R the Equivalent Dose is:

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

Justification	The process of determining whether the conduct or a set of related conducts of a Regulated Activity using Regulated Material is, overall, beneficial; that is, whether the benefits to individuals and to the society from introducing or continuing the conduct or conducts outweigh the resulting harm (including radiation detriment).
Medical Exposure	Exposure incurred by patients for the purpose of medical or dental diagnosis or treatment; by carers and comforters; and by volunteers in a programme of biomedical research involving their exposure
Medical Physicist	A health professional (an individual licensed by the competent authorities of the State to practise a profession related to health), with education and specialist training in the concepts and techniques of applying physics in medicine, competent to practise independently in one or more of the subfields (specialities) of medical physics.
Medical Radiation Technologist	A health professional (an individual licensed by the competent authorities of the State to practise a profession related to health), with specialist education and training in medical radiation technology, competent to carry out radiological procedures, on delegation from the Radiological Medical Practitioner, in one or more of the specialities of medical radiation technology.
Optimisation	The process of determining what level of Protection and Safety makes exposures, and the probability and magnitude of potential exposures, “as low as reasonably achievable, economic and social factors being taken into account” (ALARA), as required by the International Commission on Radiological Protection *System of Radiological Protection*. Optimise, Optimised and Optimizing shall be construed accordingly.

Planned Exposure Situation	A situation of exposure to Ionizing Radiation that arises from the planned Operation of a Radiation Source or from a planned Activity that results in an exposure from a Radiation Source.
Protection and Safety	The protection of people against exposure to Ionizing Radiation or Radioactive Material and the Safety of Radiation Sources, including the means for achieving this, and the means for preventing Accidents and for mitigating the consequences of Accidents should they occur.
Qualified Expert	An individual who, by virtue of certification by appropriate boards or societies, professional licences or academic qualifications and experience, is duly recognised as having expertise in a relevant field of specialisation.
Radiation Generator	A device capable of generating Ionizing Radiation, such as X-rays, neutrons, electrons or other charged particles, that may be used for scientific, industrial or medical purposes.
Radiation Protection Officer	A person technically competent in Radiation Protection matters relevant for a given type of Regulated Activity with Regulated Material who is designated by the Licensee to oversee the application of relevant requirements established in this regulation.
Radiation Weighting Factor	The number by which the Absorbed Dose in a tissue is multiplied to reflect the relative biological effectiveness of the radiation in inducing stochastic effects at low Doses, the result being the Equivalent Dose. The Radiation Weighting Factors published in “The 1990 Recommendations of the International Commission on Radiological Protection (ICRP 60)” shall be applied until the Authority determines that the revised radiation weighting factors published in “The 2007 Recommendations of the International Commission on Radiological Protection (ICRP 103)” shall be applied.

Radiological Medical Practitioner	A health professional (an individual licensed by the competent authorities of the State to practise a profession related to health), with education and specialist training in the medical uses of radiation, who is competent to independently perform or oversee procedures involving Medical Exposure in a given category.
Radiopharmacist	A health professional (an individual licensed by the competent authorities of the State to practise a profession related to health), with education and specialist training in radiopharmacy, who is competent to prepare and dispense radiopharmaceuticals used for the purposes of medical diagnosis and therapy.
Referring Medical Practitioner	A health professional (an individual licensed by the competent authorities of the State to practise a profession related to health) who, in accordance with the requirements of the State, may refer individuals to a Radiological Medical Practitioner for Medical Exposure.
Representative Person	An individual receiving a Dose that is representative of the more highly exposed individuals in the population.
Safety Culture	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.
Supplier	Any legal Person to whom a Licensee delegates duties, totally or partially, in relation to the Design, manufacture, production or Construction of a Radiation Source. An importer of a Radiation Source is considered a Supplier of a Radiation Source.
Tissue Weighting Factor	The multiplier of the Equivalent Dose to a tissue or organ 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 tissue weighting factors published in "The 1990 Recommendations of the International Commission on Radiological Protection (ICRP 60)" shall be applied until the Federal Authority for Nuclear Regulation (FANR) determines that the revised tissue weighting factors published in "The 2007

	Recommendations of the 5 International Commission on Radiological Protection" (ICRP 103) shall be applied.
Worker(s)	Any person who works full-time, part-time or on a temporary basis for a Licensee and who has recognised rights and duties in relation to occupational Radiation Protection.

Objective and Scope

Article (2)

1. This regulation defines requirements that all Licensees must comply with and follow with regard to the conduct, other than in a Nuclear Facility, of any of the following Regulated Activities with the Regulated Material referred to in Article 2(3) of this regulation:

   a. possession, use, manufacture or handling of any Regulated Material or part of any Regulated Material in the State;

   b. Storage of any Regulated Material within the State; and

   c. Disposal of any Regulated Material within the State.

2. Requirements for the Regulated Activity of transportation of Radiation Sources into or from the State are set out in the Licence conditions.

3. For the purposes of this regulation, the definition of Regulated Material in Article 1 of the Law is interpreted as follows:

   a. the Radioactive Material designated by the Authority as being subject to Regulatory Control because of its radioactivity and hence subject to the requirements of this regulation is:

      - Radioactive Material in a moderate amount (no more than one tonne) for which both the total radioactivity of an individual radionuclide present on the premises at any one time and the Activity Concentration exceeds the applicable levels given in Table I -1 of Schedule I;

      - Radioactive Material in a bulk amount for which the Activity Concentration of a given radionuclide of artificial origin exceeds the relevant value given in Table I-2 of Schedule I, and/or the Activity Concentration of any radionuclide in the uranium and thorium decay series exceeds 1 Bq/g or the Activity Concentration of K40 exceeds 10 Bq/g;

      - where there are mixtures of radionuclides, using the levels given in Tables I-1 and I-2, the condition for being subject to Regulatory Control is that the sum of the individual radionuclide activities or Activity Concentrations, as appropriate, is greater than the derived level for the mixture (X_m), determined as follows:

$$X_m = \frac{1}{\sum_{i=1}^{n} \frac{f(i)}{X(i)}}$$

- where *f(i)* is the fraction of Activity or Activity Concentration, as appropriate, of radionuclide *i* in the mixture, *X(i)* is the applicable level for radionuclide *i* as given in Table I-1 or Table I-2, and *n* is the number of radionuclides present;

b. the sources of Ionizing Radiation designated by the Authority as requiring its direct oversight and hence subject to the requirements of this regulation are those devices that generate Ionizing Radiation intended for application for medical, industrial, veterinary, legal, teaching, research, security, or agricultural purposes, including linear accelerators, cyclotrons, and fixed and mobile radiography equipment.

Article (3)

1. The requirements in this regulation apply to Planned Exposure Situations in:

   a. Facilities that contain Radiation Sources, medical radiation Facilities, veterinary radiation Facilities, Radioactive Waste Management Facilities, installations processing Radioactive Material, irradiation Facilities, and mineral extraction and mineral processing Facilities that involve or could involve exposure to radiation or exposure due to Radioactive Material; and

   b. individual Radiation Sources, including Radiation Sources within Facilities referred to in (a).

2. The requirements in this regulation apply to Occupational Exposure, Public Exposure or Medical Exposure due to any Covered Activities.

3. The application of the requirements of this regulation shall be commensurate with the characteristics of the Regulated Activity and with the magnitude and likelihood of the exposures.

Article (4)

1. It is prohibited for any Person to conduct the Covered Activities unless licensed to do so by the Authority.

2. Any Person seeking to undertake the Covered Activities shall apply to the Authority for a Licence and submit detailed evidence of Safety as in accordance with the guidance published by the Authority.

3. A Person seeking to undertake Covered Activities in a Facility (other than a Nuclear Facility) shall provide the Authority, before constructing the Facility, with technical information and data to enable the Authority to acquire an understanding of the Design of the Facility. Similarly, a Person already operating a Facility shall notify the Authority before shutting down or Decommissioning the Facility. For the purposes of this regulation Facilities shall be deemed to include locations for radiotherapy, nuclear medicine,

industrial irradiation, and predisposal Radioactive Waste Management. The Authority may identify additional such places by notice published in the Gazette.

4. The Licensee shall notify the Authority of its intentions to introduce modifications to the conduct of the Regulated Activity using Regulated Material for which they are licensed, whenever the modifications could have significant implications for Protection and Safety, and are not to carry out any such modification unless specifically authorised by the Authority.

Exemption from Regulatory Control

Article (5)

A Person may seek an Exemption by the Authority from the Regulatory Control of Regulated Material as defined in Article 2(3) of this regulation, including the need to obtain a licence, on the basis of the following criteria:

1. that in all reasonably foreseeable situations, the Effective Dose expected to be incurred by any member of the public due to the exempted Planned Exposure Situation is of the order of 10 microSieverts (μSv) or less in a year and that for low probability scenarios the Effective Dose does not exceed 1 milliSievert (mSv) in a year; or

2. Regulatory Control of the Planned Exposure Situation would provide no net benefit, in that no reasonable control measures would achieve a worthwhile return in reduction of individual Doses or risks.

Article (6)

1. Licensees may seek Clearance by the Authority on the basis that:

   a. radiation risks arising from the Radioactive Material requested to be cleared are sufficiently low so as not to warrant Regulatory Control and have no appreciable likelihood of occurrence of scenarios that could lead to a failure to meet the general criterion for Clearance; or

   b. continued Regulatory Control of the material would yield no net benefit in that no reasonable control measures would achieve a worthwhile return in terms of reduction of individual doses or of health risks.

2. The Authority may grant Clearance of Radioactive Material under Article 6(1)(a) of this regulation without further consideration provided that in all reasonably foreseeable situations the Effective Dose expected to be incurred by any member of the public due to the cleared material is of the order of 10 μSv or less in a year and for low probability scenarios that the Effective Dose expected to be incurred by any member of the public for such low probability scenarios does not exceed 1 mSv in a year.

3. The Authority may grant Clearance of Radioactive Material without further consideration provided that:

   a. The Activity Concentration of an individual radionuclide of artificial origin in solid form does not exceed the relevant level given in Table I-2 of Schedule I; or

   b. The Activity Concentrations of radionuclides of natural origin do not exceed the relevant level given in Table I-3 of Schedule I; or

   c. For radionuclides of natural origin in residues that might be recycled into construction materials or the disposal of which is liable to cause the contamination of drinking water supplies, the Activity Concentration in the residues does not exceed specific values derived so as to meet a Dose criterion of the order of 1 mSv in a year, which is commensurate with typical doses due to natural background levels of radiation.

4. The Authority may grant Clearance for specific situations (on the basis of the criteria of Article 6(1) or 6(2) of this regulation) with account taken of the physical or chemical form of the Radioactive Material and its use or the means of its Disposal. Such Clearance levels may be specified in terms of Activity Concentration per unit mass or per unit surface area.

5. For clearance of Radioactive Material containing more than one radionuclide of artificial origin, on the basis of the levels given in Table I-2, the condition for Clearance is that the sum of the individual radionuclide Activity Concentrations is less than the derived Clearance level for the mixture (X_m), determined as follows:

$$X_m = \frac{1}{\sum_{i=1}^{n} \frac{f(i)}{X(i)}}$$

   where *f(i)* is the fraction of Activity or Activity Concentration, as appropriate, of radionuclide *i* in the mixture, *X(i)* is the applicable level for radionuclide *i* as given in Table I-2, and *n* is the number of radionuclides present;

6. For Clearance of bulk quantities of material containing a mixture of radionuclides of natural origin and radionuclides of artificial origin, the conditions given in Article 6(3)(b) and Article 6(5) above both have to be satisfied.

Generic Requirements - Justification

Article (7)

1. A Person seeking to undertake the Covered Activities must establish that the undertaking of such Covered Activities has Justification.

2. With respect to the use of Ionizing Radiation in the imaging of humans for other than medical diagnosis or treatment, the Justification process shall consider:

a. appropriateness of the radiation equipment for the proposed use;

b. the use of alternative techniques that do not use Ionizing Radiation;

c. the benefits and detriments of implementing the procedure;

d. the benefits and detriments of not implementing the procedure;

e. evaluation of various radiation technologies available, including the effectiveness and limitations of the procedures;

f. availability of sufficient resources to safely conduct the imaging procedure during the intended period of use;

g. the impact of any legal or ethical issues which may be raised by the use of the technology.

3. Except for justified practices involving Medical Exposures, the following practices that result in an increase, by deliberate addition of Radioactive Material or by activation, in the radioactivity of the associated commodities or products, are deemed to be not justified:

a. practices involving food, feed, beverages, cosmetics or any other commodity or product intended for ingestion, inhalation or percutaneous intake by, or application to, a human being; and

b. practices involving the frivolous use of radiation or Radioactive Materials in commodities or products such as toys and personal jewellery or adornments.

Optimisation and Dose Limits

Article (8)

1. The Licensee shall ensure an Optimised level of Protection and Safety for Workers so that the number of people exposed and the magnitude of the individual radiation Doses are as low as reasonably achievable (bearing in mind economic and social factors).

2. The Licensee shall determine a Dose Constraint for exposure of Workers taking into account international good practice in similar Facilities and Activities and shall Optimise protection below that nominated Dose Constraint. Where relevant, the Dose Constraint shall serve as a design target.

Article (9)

1. The Licensee shall ensure an Optimised level of Protection and Safety for members of the public so that the number of people exposed and the magnitude of the individual radiation Doses are as low as reasonably achievable (bearing in mind economic and social factors).

2. The Licensee shall determine a Dose Constraint for exposure of members of the public taking into account international good practice in similar Facilities and Activities, and shall

Optimise protection below that nominated Dose Constraint. Where relevant, the Dose Constraint shall serve as a design target.

3. The public Dose Constraint determined in Article 9(2) above shall be subject to the agreement of the Authority.

Article (10)

1. The Licensee shall ensure that the normal exposure of Workers does not exceed the Dose limits established in Articles 10(2) and (3) below.

2. The limit for the Effective Dose to a Worker who receiving Occupational Exposure is an average of 20 mSv per year averaged over a period of five years (100 mSv in 5 years), and 50 mSv in any one year.

3. The annual Equivalent Dose in the lens of the eye of a Worker shall not exceed 20 mSv in a year, averaged over defined periods of 5 years, with no single year exceeding 50 mSv, nor shall the annual Equivalent Dose exceed 500 mSv at any point on the hands, feet or skin. The equivalent dose limits to the skin apply to the average dose over 1 cm^2 of the most highly irradiated area of the skin.

4. When a female Worker receiving Occupational Exposure during normal Operation and has announced her pregnancy, the Licensee shall arrange her work so that the Equivalent Dose to the foetus is as low as reasonably achievable and shall not exceed 1 mSv for the remainder of the pregnancy.

Article (11)

1. The Licensee shall ensure that the normal exposure of the public does not exceed the Dose limits established in Article 11(2) below.

2. The limit for the annual Effective Dose to a member of the public (this includes people working in the Facility other than those categorised as Workers) is 1 mSv. The annual Equivalent Dose in the lens of the eye shall not exceed 15 mSv, nor shall the annual Equivalent Dose at any point on the skin exceed 50 mSv.

Management Requirements

Article (12)

1. The Licensee has the prime responsibility for Protection and Safety, and shall establish and implement a Protection and Safety programme appropriate for the conduct of the Regulated Activity. The Protection and Safety programme shall:

   a. The Protection and Safety programme shall be based on a documented Safety Assessment that identifies the sources of routine and reasonably foreseeable potential exposures; provides a realistic estimate of the resulting Doses and their probabilities;

and identifies the resulting radiological protection measures that are needed. The Safety Assessment shall be proportionate to the complexity and radiation risks of the Licensee's Activities and may be generic;

b. apply Protection and Safety measures commensurate with the nature and extent of the radiation risks associated with the Regulated Activity and sufficient to ensure compliance with the requirements of this regulation and any Licence conditions that the Authority imposes;

c. identify the role of the Radiation Protection Officer(s); and

d. ensure that any delegation of responsibilities, including to Radiation Protection Officers, is documented.

2. The Licensee shall ensure that, in the implementation of the Protection and Safety programme:

a. the measures and resources needed to achieve the Protection and Safety objectives are determined and duly provided;

b. the Protection and Safety programme is periodically reviewed to assess its effectiveness and continued fitness for the purpose; and

c. any failures or shortcomings in Protection and Safety are identified and rectified, and steps taken to prevent their recurrence.

3. The Licensee shall ensure that all personnel engaged in activities relevant to Protection and Safety are educated, trained and qualified so that they understand their responsibilities and perform their duties competently with appropriate judgment and according to defined procedures.

4. The Licensee shall ensure that Qualified Experts are identified and consulted, as necessary, on the proper observance of this regulation.

5. The Licensee shall establish a Quality Assurance programme as necessary as a part of its Management System to address Protection and Safety associated with Radiation Sources and the risk and complexity of the associated Activities.

Article (13)

1. The Licensee shall demonstrate commitment to Protection and Safety at the highest levels within its organisation. The Licensee shall ensure that Protection and Safety are effectively integrated into its overall Management System, which shall be designed and implemented to enhance safety by:

a. applying the requirements for Protection and Safety coherently with other requirements, including those for operational performance and for security;

b. describing the planned and systematic actions necessary to provide adequate confidence that the requirements for Protection and Safety are satisfied;

c. ensuring that Protection and Safety are not compromised by other requirements or demands; and

d. providing for the regular Assessment of Protection and Safety performance and the application of lessons learned from experience.

2. The Licensee shall ensure that Protection and Safety aspects of the Management System are commensurate with the complexity and the radiation risks of the Regulated Activity, as assessed through a Safety Assessment, and shall demonstrate the effective fulfilment of the Management System requirements for Protection and Safety.

3. The Licensee shall foster and maintain a strong Safety Culture as a part of its Management System by:

a. promoting individual and collective commitment to Protection and Safety at all levels of the organisation;

b. ensuring a common understanding of the key aspects of Safety Culture within the organisation;

c. providing the means by which the organisation supports individuals and teams in carrying out their tasks safely and successfully, taking into account the interaction between individuals, technology and the organisation;

d. encouraging the participation of Workers in the development and implementation of policies, rules and procedures dealing with Protection and Safety;

e. ensuring accountability of the organisation and of individuals at all levels for Protection and Safety;

f. encouraging open communication within the organisation and with other relevant parties, as appropriate;

g. encouraging a questioning and learning attitude and discouraging complacency with regard to Protection and Safety; and

h. providing the means by which the organisation continually seeks to develop and improve its Safety Culture.

4. The Licensee shall take into account human factors and support good performance and good practices to prevent human and organisational failures, by ensuring that:

a. sound ergonomic principles are followed in designing equipment and operating procedures, so as to facilitate the safe operation or use of equipment, to minimise the

possibility that operating errors will lead to Accidents, and to reduce the possibility of misinterpreting indications of normal and abnormal conditions;

b. appropriate equipment, safety systems, and procedural requirements are provided and other necessary provisions are made:

- to reduce, to as low as reasonably achievable, economic and societal factors being taken into account, the possibility that human error or inadvertent action could give rise to Accidents or other events causing exposures;
- to provide means for detecting human errors and for correcting or compensating for them; and
- to facilitate corrective actions in the event of failure of safety systems or of other protective measures.

Article (14)

1. The Licensee shall establish and implement the necessary technical and organisational measures that are needed for ensuring Protection and Safety of the Activity for which they are licensed. The Licensee may appoint other Qualified Experts to carry out actions and tasks related to these responsibilities, but shall retain the responsibility for the actions and tasks themselves. The Licensee has to identify the Qualified Experts and other people appointed to ensure compliance with this regulation.
2. The Licensee shall:

a. establish clear lines of responsibility and accountability for Protection and Safety of the Radiation Sources for which they are licensed throughout their operational lifetime, and establish organisational arrangements for Protection and Safety;

b. assess the likely consequences of potential exposures, their magnitude and probability of occurrence, and the number of people who may be affected by them;

c. have in place operating procedures and arrangements to maintain Safety that are subject to periodic review and updating under the Management System;

d. establish procedures for reporting and learning from Accidents and incidents;

e. establish arrangements for the periodic review of the overall effectiveness of the Protection and Safety measures;

f. ensure that Maintenance, testing, Inspection and servicing is carried out as needed so that Radiation Sources remain capable of meeting their Design requirements for Protection and Safety throughout their lifetime; and

g. ensure safe control and management of all Radioactive Waste that is generated, in accordance with Article 30 of this regulation.

Prevention of Accidents

Article (15)

1. The Licensee shall ensure that a multilayer system of provisions for Protection and Safety, commensurate with the magnitude and likelihood of the potential exposures involved, is applied to Radiation Sources for which they are authorised, such that a failure at one layer is compensated for or corrected by subsequent independent layers.

2. The Licensee shall make suitable arrangements to:

   a. prevent, as far as reasonably achievable, Accidents that have been postulated in connection with the Facility or Activity;

   b. mitigate the consequences of any Accident that does occur;

   c. provide Workers with the information, training, and equipment necessary to restrict potential exposures;

   d. ensure that there are adequate procedures for the control of the Facility and of any potential Accident that has been postulated;

   e. ensure that safety significant systems, including software, components and equipment can be inspected and tested regularly for any degradation that could lead to abnormal conditions or inadequate performance;

   f. ensure that Maintenance, Inspection and testing appropriate to the preservation of the Protection and Safety provisions can be carried out without undue Occupational Exposure;

   g. provide, wherever appropriate, automatic systems for safely shutting off or reducing radiation output from Facilities in the event that operating conditions exceed the operating ranges;

   h. ensure that abnormal operating conditions that could significantly affect Protection and Safety are detected by systems that respond quickly enough to allow for timely corrective action to be taken; and

   i. ensure that all relevant Safety documentation is available in the appropriate languages.

Emergency Plan

Article (16)

1. The Licensee shall prepare and maintain an Emergency Plan for protection of people, commensurate with the nature and magnitude of the risk involved. The Emergency Plan shall be subject to the approval of the Authority.

2. The Licensee shall be responsible for the implementation of the Emergency Plans and shall be prepared to take any necessary action for effective response.

3. To prevent the occurrence of situations that could lead to a loss of control over a Radiation Source or the escalation of such situations, the Licensee shall:

    a. develop, maintain and implement procedures to provide the means for preventing loss of control and regaining control over the Radiation Source as necessary;

    b. make available equipment, instrumentation and diagnostic aids that may be needed; and

    c. train personnel and periodically retrain them in the procedures to be followed.

Operating Experience

Article (17)

1. The Licensee shall ensure that information on both normal Operation and abnormal circumstances significant to Protection and Safety is provided to the Authority.

2. The Licensee shall conduct formal investigations of abnormal circumstances arising in the operation of Facilities excluding Nuclear Facilities, or the conduct of Activities, and shall provide the Authority as soon as possible with information that is significant to Protection and Safety.

3. The Licensee shall conduct formal investigations and produce a written report in the event that:

    a. A quantity or operating parameter related to Protection and Safety exceeds an investigation level or is outside the stipulated range of Operating conditions; or

    b. any equipment failure, Accident, error, mishap or other unusual event or circumstance occurs which has the potential for causing a quantity to exceed any relevant limit or Operating restriction.

4. The Licensee shall:

   a. conduct an investigation as soon as possible after the event and produce a written report on its cause, with a verification or determination of any Doses received or committed and recommendations for preventing the recurrence of similar events;

   b. communicate to the Authority and to any other relevant competent authorities, a summary report of any formal investigation of events, including exposures greater than the Dose limits established in Articles 10 and 11 of this regulation; and

   c. report to the Authority (and other competent authorities as necessary) within 24 hours any event where the Dose limits established by Articles 10 and 11 of this regulation are exceeded.

Safety of Generators and Radioactive Sources

Article (18)

1. The Licensee shall ensure the Safety of radiation generators, Radioactive Sources, and devices containing a Radioactive Source.

2. Licensees, in co-operation with Suppliers, shall ensure that the following responsibilities are discharged:

   a. to provide a well designed and constructed radiation generator or Radioactive Source and device in which the radiation generator or Radioactive Source is used that:

      - provides for Protection and Safety in compliance with this regulation;
      - meets engineering, performance and functional specifications;
      - meets international safety standards;
      - meets quality standards commensurate with the Protection and Safety significance of components, systems and software; and
      - provides displays, dials and instructions on operating consoles in a language understood and acceptable to the user;

   b. to ensure that radiation generators and Radioactive Sources are tested to demonstrate compliance with the appropriate specifications;

   c. to make available information, in a language that is easily understood and acceptable to the user, concerning the proper installation and use of the radiation generator or Radioactive Source and its associated risks, including performance specifications, operating and Maintenance instructions, and Protection and Safety instructions.

3. When choosing a location to use or store a radiation generator or Radioactive Source, the Licensee shall take into account:

   a. factors that could affect the Safety and security of the radiation generator or Radioactive Source;

   b. factors that could affect the Occupational Exposure and Public Exposure caused by the radiation generator or Radioactive Source; and

   c. the feasibility in engineering Design of taking into account the foregoing factors.

4. When selecting a site for a Facility that will hold a large amount of Radioactive Material and has the potential for releases of large amounts of such Radioactive Material, the Licensee shall take into account any features that might affect Protection and Safety, features that might affect the integrity or function of the Facility, and the feasibility of carrying out off-site protective actions when they become necessary.

5. The Licensee shall keep radiation generators and Radioactive Sources secure so as to prevent loss, theft or damage and to prevent any unauthorised people from carrying out any of the Covered Activities.

6. The Licensee shall ensure that:

   a. a radiation generator or Radioactive Source is not transferred unless the receiver possesses the necessary authorization;

   b. the Authority is notified before the receipt or transfer of any radiation generator or Radioactive Source, including the type, form, and quantity of radiation generators or Radioactive Sources; and

   c. the Authority is notified of information regarding any uncontrolled, lost or missing radiation generator or Radioactive Source in accordance with the requirements in Article 19 of this regulation.

7. The Licensee shall maintain an inventory that includes records of:

   a. the location and description of each radiation generator or Radioactive Source for which they are responsible; and

   b. the Activity and form of each Radioactive Source for which they are responsible.

8. The Licensee shall:

   a. share appropriate information from their radiation generator or Radioactive Source inventory records with the Authority or other designated body when requested by the Authority;

   b. in cooperation with the manufacturer of a Radioactive Source or a device containing a Radioactive Source, ensure that, where practicable, the Radioactive Source itself and

its container are marked with the symbol recommended by the International Organisation for Standardization (ISO);

c. in cooperation with manufacturers, ensure that, where practicable, sealed Radioactive Sources are identifiable and traceable;

d. ensure that when Radioactive Sources are not in use they are stored in an appropriate manner such that Protection and Safety is maintained; and

e. ensure that arrangements are made for the safe management and disposition of Radioactive Sources, including financial provisions where appropriate, once they are no longer used.

Reporting Requirements

Article (19)

1. Four hour report: The Licensee shall notify the Authority as soon as possible, but not later than four hours after:

   a. the discovery of a loss of an Category 1, 2 or 3 Radioactive Source as defined in the IAEA Safety Guide RS-G-1.9 'Categorization of Radioactive Sources';

   b. an event that requires immediate protective actions necessary to avoid exposure to Ionizing Radiation or Regulated Materials that could exceed Dose limits; or

   c. releases of Regulated Material that could exceed regulatory limits (events may include theft, road Accidents, fires, explosions).

   d. an event that requires unplanned medical treatment at a medical facility of an individual with transferrable radioactive contamination on his or her clothing or body;

   e. Any event or situation, related to the health and safety of the public or onsite personnel or protection of the environment for which a news release is planned or notification to other government agencies has been or will be made. Such an event may include an onsite fatality or inadvertent release of radioactively contaminated materials.

2. Twenty-four hour report: The Licensee shall notify the Authority within 24 hours after the discovery of any of the following events involving Regulated Material:

   a. loss of a Category 4 Radioactive Source as defined in the IAEA Safety Guide RS-G-1.9 'Categorization of Radioactive Sources;

   b. an unplanned contamination event that requires access to the contaminated area to be restricted for more than 24 hours by imposing additional radiological controls or by prohibiting entry into the area;

c. an event in which equipment is disabled or fails to function as designed when the equipment is required to prevent releases or exposures exceeding regulatory limits, or to mitigate the consequences of an Accident, and no redundant equipment is available and operable to perform the required Safety function;

d. an event that requires unplanned medical treatment at a medical facility of an individual with spreadable radioactive contamination on the individual's clothing or body;

e. an Accident, fire or explosion that damages any Regulated Material or any device, container, or equipment containing Regulated Material when the quantity involved is equivalent to a Category 4 or greater Radioactive Source and the damage affects the integrity of the Regulated Material or its container; or

f. an event where a Dose limit is exceeded.

3. One week report The Licensee shall notify the Authority within seven days after the discovery of any of the following events involving Regulated Material:

   a. any Discharges exceeding the authorised limits of Discharge in accordance with reporting criteria established by the Authority; or

   b. any significant increase in Dose rate or content of radionuclides in the environment that could be attributed to authorised Activities.

4. Thirty day report The Licensee shall submit to the Authority within 30 days any report required by Article 41(4)(d) of this regulation concerning unintended or accidental Medical Exposures.

5. The requirements of this Article do not alter the Licensee's obligations to notify other relevant competent authorities in relation to an incident.

Occupational Exposure - Responsibility of the Licensee for Optimisation of Protection and Safety

Article (20)

1. The Licensee is responsible for the protection of Workers against Occupational Exposure and shall ensure that Protection and Safety is Optimised and the Dose limits for Occupational Exposure are not exceeded.

2. Where persons who are not employed by the Licensee are subject to Occupational Exposure, the Licensee shall co-operate with the employer so that:

   a. the measures for Protection and Safety applied for these persons are at least as good as for Workers of the Licensee;

   b. there are specific assessments of the Doses received by these persons, as appropriate; and

c. there is a clear allocation of the responsibilities of the employer and those of the Licensee for Protection and Safety.

As part of the co-operation between the Licensee and the employer, the Licensee shall, as appropriate:

a. obtain from the employer, including self-employed individuals, the previous occupational history of the persons to be subject to Occupational Exposure by the Licensee and any other necessary information

b. provide appropriate information to the employer, including any available information relevant for compliance with this regulation that the employer requests

c. provide both the persons subject to Occupational Exposure and the employer with the relevant exposure records.

3. The Licensee shall ensure, for all Workers engaged in Activities that involve or could involve Occupational Exposure, that:

a. Occupational Exposures are so controlled that the relevant Dose limits for Occupational Exposure specified in Article 10 of this regulation are not exceeded;

b. occupational Protection and Safety are Optimised;

c. decisions regarding measures for occupational Protection and Safety are recorded and made available to the Authority;

d. policies, procedures and organisational arrangements for Protection and Safety are established for implementing the relevant requirements of this regulation, with priority given to Design and technical measures for controlling Occupational Exposures;

e. suitable and adequate Facilities, equipment and services for Protection and Safety are provided, the nature and extent of which are commensurate with the expected magnitude and likelihood of the Occupational Exposure;

f. necessary Workers' health surveillance and health services are provided;

g. appropriate protective devices and monitoring equipment are provided and arrangements made for their proper use (as required in Articles 23 to 26 of this regulation;

h. suitable and adequate human resources and appropriate training in Protection and Safety are provided, as well as periodic retraining and updating as required in order to ensure the necessary level of competence;

i. adequate records are created and maintained as required by this regulation;

j. arrangements are made to facilitate consultation and cooperation with Workers with respect to Protection and Safety about all measures necessary to achieve the effective implementation of this regulation; and

k. necessary conditions to promote a Safety Culture are provided as required by Article 13 of this regulation.

l. Workers fulfil their obligations and carry out their duties for Protection and Safety and that they:

- follow all rules and procedures for Protection and Safety specified by the Licensee;
- use monitoring equipment and personal protective equipment properly;
- cooperate with the Licensee with regard to Protection and Safety, to programme for Workers' health surveillance, and to programme for Dose Assessment;
- provide the Licensee with information on their past and present work that is relevant for their own Protection and Safety as well as that of others;
- abstain from any wilful action that could create situations contrary to the requirements of this regulation;
- accept any information, instruction and training needed to enable them to work in accordance with this regulation.
- report to the Licensee as soon as possible any circumstances that could adversely affect Protection and Safety.

4. The Licensee shall ensure that Workers exposed to radiation from Radiation Sources within Activities that are not directly related to their work or not required by their work, receive the same level of protection as if they were members of the public.

Controlled and Supervised Areas

Article (21)

1. The Licensee shall designate as a controlled area any area in which specific protective measures or safety provisions are or could be required for:

   a. controlling normal exposures;

   b. preventing the spread of contamination during normal working conditions; or

   c. preventing or limiting the extent of potential exposures.

2. In determining the boundaries of any controlled area, the Licensee shall take account of the magnitudes of the expected normal exposures, the likelihood and magnitude of

potential exposures and the nature and extent of the required Protection and Safety procedures.

3. The Licensee shall:

   a. delineate controlled areas by physical means or, where this is not reasonably practicable, by some other suitable means;

   b. where a Radiation Source is brought into Operation or energized only intermittently or is moved from place to place, delineate an appropriate controlled area by means that are appropriate under the prevailing circumstances and specify exposure times;

   c. display the symbol for Ionizing Radiation recommended by the ISO and appropriate instructions at access points and other appropriate locations within controlled areas;

   d. establish occupational Protection and Safety measures including, as appropriate, physical measures and local rules and procedures for controlled areas to control the spread of contamination;

   e. restrict access to controlled areas by physical barriers, which could include locks or interlocks, or if necessary, by means of administrative procedures, such as the use of work permits, the degree of restriction being commensurate with the magnitude and likelihood of the expected exposures;

   f. provide, as appropriate, at entrances to controlled areas:

      - protective clothing and equipment,
      - individual and workplace monitoring equipment, and
      - suitable Storage for personal clothing.

   g. provide, as appropriate, at exits from controlled areas:

      - equipment for monitoring for contamination of skin and clothing,
      - equipment for monitoring for contamination of any object or substance being removed from the area,
      - washing or showering facilities, and
      - suitable Storage for contaminated protective clothing and equipment.

   h. periodically review conditions to determine the possible need to revise the protective measures or Safety provisions or the boundaries of controlled areas.

4. The Licensee shall designate as a supervised area any area not already designated as a controlled area but where Occupational Exposure conditions need to be kept under review even though specific protective measures and Safety provisions are not normally needed.

5. The Licensee shall take into account the nature, likelihood and extent of radiation hazards in the supervised areas and:

   a. delineate the supervised areas by appropriate means;

   b. display approved signs at appropriate access points to supervised areas; and

   c. periodically review the conditions to determine any need for protective measures and safety provisions or changes to the boundaries of supervised areas.

6. The Licensee shall minimise the need to rely on administrative controls and personal protective equipment for achieving Protection and Safety by maximizing the provision of well-engineered controls and satisfactory working conditions, in accordance with the following hierarchy of prevention principles:

   a. engineered controls;

   b. administrative controls; and

   c. personal protective equipment.

Local Rules and Personal Protective Equipment

Article (22)

1. The Licensee shall:

   a. establish in writing such local rules and procedures as are necessary to ensure adequate levels of Protection and Safety for Workers and other people;

   b. include in the local rules and procedures the values of any relevant investigation level or authorised level, and the procedure to be followed in the event that any such value is exceeded;

   c. make the local rules and procedures and the protective measures and safety provisions known to those Workers to whom they apply and to other people who may be affected by them;

   d. ensure that any work involving Occupational Exposure is adequately supervised and take all reasonable steps to ensure that the rules, procedures, protective measures and safety provisions are observed; and

   e. designate, as appropriate, a Radiation Protection Officer.

2. The Licensee shall ensure that:

   a. Workers are provided with suitable and adequate personal protective equipment which meets relevant standards or specifications, including as appropriate:

      - protective clothing,
      - protective respiratory equipment for which the protection characteristics are made known to the users, and
      - protective aprons and gloves and organ shields;

   b. when appropriate, Workers receive adequate instruction in the proper use of respiratory protective equipment, including testing for good fit;

   c. tasks requiring the use of specific personal protective equipment are assigned only to Workers who on the basis of medical advice are capable of safely sustaining the extra effort necessary;

   d. all personal protective equipment, including equipment for use in an Emergency, is maintained in proper condition and, if appropriate, is tested at regular intervals; and

   e. if the use of personal protective equipment is considered for any given task, account is taken of any additional exposure that could result owing to the additional time or inconvenience, and of any additional non-radiological risks that might be associated with performing the task while using protective equipment.

Workplace Monitoring

Article (23)

1. The Licensee shall establish, maintain and keep under review a programme for the monitoring of the workplace under the supervision of a Radiation Protection Officer or other Qualified Experts.

2. The nature and frequency of monitoring of workplaces shall:

   a. be sufficient to enable:

      - evaluation of the radiological conditions in all workplaces;
      - exposure Assessment in controlled areas and supervised areas; and
      - review of the classification of controlled and supervised areas; and

   b. depend on the levels of ambient Dose rate and Activity Concentration in air, including their expected fluctuations and the likelihood and magnitude of potential exposures.

3. The Licensee shall keep records of the findings of the workplace monitoring programme which shall be made available to Workers.

Personnel Monitoring

Article (24)

1. The Licensee shall be responsible for making arrangements for Assessment of the Occupational Exposure of Workers and for their health surveillance.

2. The Licensee shall be responsible for making arrangements for the Assessment of the Occupational Exposure of Workers, on the basis of individual monitoring, and shall ensure that adequate arrangements are made with approved/licensed dosimetry services that operate under an adequate quality Management System and are approved by a certifying organisation acceptable to the Authority.

3. The Licensee shall ensure that individual monitoring is undertaken for any Worker who is normally employed in a controlled area, or who occasionally works in a controlled area and may receive significant Occupational Exposure. In cases where individual monitoring is inappropriate, inadequate or not feasible, the Licensee shall ensure that Occupational Exposure of the Worker is assessed on the basis of the results of monitoring of the workplace and on information on the locations and durations of exposure of the Worker.

4. The Licensee shall ensure that the Occupational Exposure of any Worker who is regularly employed in a supervised area or who enters a controlled area only occasionally is assessed on the basis of the results of monitoring of the workplace and individual monitoring.

5. The Licensee shall ensure that Workers, who may be exposed to contamination, including Workers who use protective respiratory equipment, are identified and shall arrange for appropriate monitoring to the extent necessary to demonstrate the effectiveness of the protection provided and to assess the intake of Radioactive Materials or the committed Effective Doses, as appropriate.

Monitoring of Compliance

Article (25)

1. The Licensee shall ensure that:

   a. monitoring and measurements are performed of the parameters necessary for verification of compliance with the requirements of this regulation;

   b. suitable equipment is provided and verification procedures implemented;

   c. the equipment is properly maintained, tested and calibrated at appropriate intervals with reference to standards traceable to national or international standards; and

d. monitoring records include records of the monitoring equipment tests and calibrations carried out in accordance with this regulation.

Article (26)

1. The Licensee shall maintain Dose records for each Worker for whom Assessment of Occupational Exposure is required under Article 24 of this regulation.

2. The Licensee shall ensure that the exposure records for each Worker shall be preserved during the Worker's working life and afterwards at least until the Worker attains or would have attained the age of 75 years, and for not less than 30 years after the termination of the work involving Occupational Exposure.

3. The exposure records shall include:

   a. information on the general nature of the work involving Occupational Exposure and the dates during which the Worker was employed;

   b. information on Doses, exposures and intakes at or above the relevant recording levels and the data upon which the Dose Assessments have been based; and

   c. records of any Doses, exposures and intakes due to actions taken in an Emergency or due to Accidents, which shall be distinguished from Doses, exposures or intakes during normal work and which shall include references to reports of any relevant investigations.

4. The Licensee shall:

   a. provide for access by Workers to the information in their own exposure records;

   b. provide for access to the exposure records by the supervisor of the Workers' health surveillance programme, and by the Authority;

   c. facilitate the provision of copies of Workers' exposure records to new employers when Workers change employment;

   d. report the Doses received by each Worker to the Authority during each half of the year within two months of the end of that half;

   e. when a Worker ceases to work, make arrangements for the retention of the Worker's exposure records by the Authority; and

   f. in complying with (a) to (e), give due care and attention to the appropriate confidentiality of records.

5. If the Licensee ceases Activities that involve Occupational Exposure of Workers, they shall make arrangements for the retention of Workers' exposure records by the Authority.

6. In accordance with Article 20(3)(f) of this regulation, Workers' health surveillance programme shall be:

   a. based on the general principles of occupational health; and

   b. designed to assess the initial and continuing fitness of Workers for their intended tasks.

7. If one or more Workers are to be engaged in work that involves or could involve exposure from a Radiation Source that is not under the control of their employer, the Licensee responsible for the Radiation Source shall, as a precondition for such engagement, make any special arrangements for Workers' health surveillance with the employer which are needed to comply with the rules established by the Authority.

Information, Training and Special Requirements

Article (27)

The Licensee shall:

a. provide to all Workers adequate information on the health risks due to their Occupational Exposure, whether normal exposure or potential exposure, adequate instruction and training on Protection and Safety and adequate information on the significance for Protection and Safety of their actions;

b. provide appropriate information, instruction and training to those Workers who could be affected by or involved in the response to an Emergency; and

c. keep records of the training provided to individual Workers.

Article (28)

1. The Licensee shall not offer benefits as a substitute for Protection and Safety measures required by this regulation. In particular:

   a. Workers' conditions of service shall be independent of whether they are or could be subject to Occupational Exposure, and

   b. Licensees shall make all reasonable efforts to provide Workers with suitable alternative employment when the Workers, for health reasons, may no longer continue in employment in which they are or could be subject to Occupational Exposure.

2. The Licensee shall make special arrangements for female Workers necessary for the protection of the embryo and foetus and of breast-feeding infants, and for the protection of people under 18 years of age, from exposure to radiation.

3. The Licensee shall provide to female Workers who are liable to enter controlled or supervised areas or who may undertake Emergency duties, appropriate information on:

   a. the risk to the embryo or foetus due to exposure of a pregnant woman;

   b. the importance for a female Worker of notifying her employer as soon as she suspects that she is pregnant or she is breast feeding; and

   c. the risk to an infant ingesting radioactive substances by breast feeding.

4. The Licensee shall not use the notification of pregnancy or breast feeding as a reason to exclude a female Worker from work.

5. The Licensee shall ensure that a female Worker who has notified the Licensee of her pregnancy or breast feeding has working conditions in respect of Occupational Exposure so as to ensure that the embryo, foetus or infant is afforded the same broad level of protection as that required for members of the public.

6. The Licensee shall ensure that no person under the age of 18 years is allowed to work in a controlled area unless under supervision and then only for the purpose of training for employment involving exposure to radiation or for students who are required to use Radiation Sources in the course of their studies.

7. The Licensee shall ensure that no person under the age of 16 years is subjected to Occupational Exposure.

Public Exposure - Responsibility of the Licensee for Optimisation of Protection and Safety

Article (29)

1. The Licensee, in applying the principle of Optimisation of Protection and Safety shall take into account:

   a. potential changes in any condition that could affect Public Exposure, such as changes in the characteristics and Operation of the Radiation Source, changes in environmental dispersion conditions, changes in exposure pathways, or changes in parameters used for the determination of the Representative Person;

   b. current good practice in the Operation of similar Facilities and Activities;

   c. build-up and accumulation of discharged Radioactive Materials in the environment during the lifetime of a Radiation Source; and

   d. uncertainties in the Assessment of exposures, especially in contributions to the exposures if the Radiation Source and the Representative Person are separated in distance or time.

2. The Licensee shall, with respect to the Radiation Sources under their responsibility, establish, implement and maintain:

   a. Protection and Safety policies, procedures and organisational arrangements in relation to Public Exposure in fulfilment of the requirements of this regulation;

   b. measures for ensuring:

      - the Optimisation of the protection, and
      - the limitation of the exposure of the members of public, which results from such Radiation Sources, in accordance with this regulation;

   c. measures for ensuring the Safety of such Radiation Sources;

   d. suitable and adequate resources (such as facilities, equipment and services for the protection of the public) commensurate with the magnitude and likelihood of the exposure;

   e. appropriate training to the personnel having functions relevant to the protection of the public, as well as periodic retraining and updating as necessarily required, in order to ensure the necessary level of competence;

   f. appropriate monitoring equipment, surveillance programme and methods to assess Public Exposure;

   g. adequate records of the surveillance and monitoring; and

   h. Emergency Plans, procedures and arrangements, as required by Article 16 of this regulation.

3. The Licensee shall:

   a. apply the relevant requirements of this regulation regarding Public Exposure to visitors to a controlled area or supervised area;

   b. ensure that visitors are accompanied in any controlled area by a Worker knowledgeable about the Protection and Safety measures for that area;

   c. provide adequate information and instruction to visitors before they enter a controlled area so as to ensure appropriate protection of the visitors and of other individuals who could be affected by their actions; and

   d. ensure that adequate control over entry of visitors to a controlled area or supervised area is maintained, including the appropriate use of signs in all relevant languages in such areas.

4. The Licensee, shall ensure that, if a Radiation Source can cause exposure to the public:

   a. the floor plans and equipment arrangements for all new installations, utilizing such Radiation Sources, as well as all significant modifications to existing installations, are subject to review and approval by the Authority prior to Commissioning; and

   b. shielding and other protective measures including access control are provided as appropriate for restricting Public Exposure, in particular at open sites such as for some applications of industrial radiography.

5. The Licensee shall ensure, as appropriate, that:

   a. specific confinement provisions are established for the Design and Operation of a Radioactive Source that could cause spread of contamination in areas accessible to the public; and

   b. protective measures are implemented for restricting Public Exposure to contamination in areas accessible to the public within a Facility.

Radioactive Waste

Article (30)

1. The Licensee shall ensure that Radioactive Waste is managed in accordance with the Licence and that Discharges of Radioactive Material to the environment are within the limits stated by the Authority in the Licence.

2. The Licensee shall:

   a. ensure that the Activity and volume of any Radioactive Waste generated from the Radioactive Sources are kept to the minimum practicable, when Optimising Protection and Safety, and that the Radioactive Waste is managed in accordance with the requirements of this regulation;

   b. segregate and treat separately, if appropriate, different types of Radioactive Waste where warranted by differences in factors such as radionuclide content, half-life, concentration, volume and physical and chemical properties, taking into account the available options for the Storage and Disposal of Radioactive Waste; and

   c. maintain an inventory of all Radioactive Waste (generated, Discharged, stored, or transferred) and the physical and chemical characteristics of the Radioactive Waste.

3. The Licensee in applying for an authorization for Discharge, shall:

   a. determine the characteristics and Activity of the Radioactive Material to be Discharged, and the potential locations and methods of Discharge;

   b. determine by an appropriate pre-operational study all significant exposure pathways by which Discharged radionuclides could deliver Public Exposure;

c. assess the Doses to the Representative Person due to the planned Discharges;

d. consider the radiological environmental impact, as required by the Authority;

e. submit the information in (a) to (d) above to the Authority as an input to the establishment by the Authority of authorised limits on Discharge and conditions for their implementation.

4. The Licensee shall in agreement with the Authority, review and adjust their Discharge control measures, taking into account:

a. operating experience; and

b. any changes in exposure pathways and the characteristics of the Representative Person that could affect the Assessment of Doses due to the Discharges.

Monitoring of Public Exposure

Article (31)

The Licensee shall, as appropriate:

1. establish and implement a monitoring programme to ensure that Public Exposure in relation to Radiation Sources under their responsibility is adequately assessed, and sufficient to demonstrate compliance with the Licence. This programme shall include the following, as appropriate:

a. external exposure from the Radiation Sources,

b. Discharges,

c. radioactivity in the environment, and

d. other parameters important for the Assessment of Public Exposure;

2. keep appropriate records of the results of the monitoring programme and estimated exposures;

3. report the results of the monitoring programme to the Authority at approved intervals, including the levels and composition of Discharges, Dose rates at the site boundary and in premises open to members of the public, results of environmental monitoring, results of retrospective Assessments of Doses to the Representative Person;

4. carrying out Emergency monitoring, in case of unexpected increases in radiation levels or content of radionuclides in the environment due to accidental or other unusual events attributed to their authorised Radiation Source or Facility; and

5. verify the adequacy of the assumptions made for the Assessment of Public Exposure and environmental impact.

Medical Exposure - Responsibility of the Licensee for Optimisation of Protection and Safety

Article (32)

1. The Licensee shall ensure that no person receives a Medical Exposure unless there has been appropriate referral, Protection and Safety are assured, and the person to be exposed has been informed as appropriate.

2. The Licensee shall ensure that no patient, whether symptomatic or not, receives a Medical Exposure unless:

   a. the examination or treatment has been requested by a Referring Medical Practitioner and information on the clinical context has been provided, or is part of an health screening programme approved by the Ministry of Health;

   b. the Medical Exposure has been justified by the Radiological Medical Practitioner, in consultation with the Referring Medical Practitioner when appropriate, or is part of an approved health screening programme;

   c. a Radiological Medical Practitioner has taken responsibility as specified in Article 32(5)(a) below; and

   d. the patient has been informed, as appropriate, of the potential benefit of the radiological procedure as well as the radiation risks.

3. The Licensee shall ensure that no individual receives a Medical Exposure as part of a biomedical research programme unless it has been approved by an ethics committee (or other institutional body assigned similar functions by the relevant competent authority), and a Radiological Medical Practitioner has taken responsibility as specified in Article 32(5)(a) below and that Dose Constraints specified or approved by the ethics committee are used in the Optimisation of Protection and Safety for persons exposed.

4. The Licensee shall ensure that no individual receives a Medical Exposure as a carer or comforter unless he or she has received, and has indicated an understanding of, relevant information on Radiation Protection and radiation risks prior to providing support and comfort to an individual undergoing diagnosis or treatment, and that relevant Dose Constraints are applied to the Optimisation of Protection and Safety.

5. The Licensee shall ensure that:

   a. the Radiological Medical Practitioner performing or overseeing the radiological procedure has assumed responsibility for ensuring overall patient Protection and Safety during the planning and delivery of the Medical Exposure, including the Justification of the procedure as required in Article 33 of this regulation and the Optimisation of protection, in cooperation with the Medical Physicist and the Medical Radiation Technologist, as required in Article 34 of this regulation;

b. Radiological Medical Practitioners, Medical Physicists, Medical Radiation Technologists and other Qualified Experts with specific duties in patient protection involved in a given radiological procedure have the appropriate specialisation;

c. sufficient medical and paramedical personnel are available as specified by the relevant health competent authority;

d. for therapeutic uses of radiation, the calibration, dosimetry and Quality Assurance (including medical radiological equipment acceptance and Commissioning) requirements of this regulation, specified in Articles 35 to 38 of this regulation are conducted by or under the supervision of a Medical Physicist;

e. for diagnostic and image-guided interventional uses of radiation, the imaging, calibration, dosimetry and Quality Assurance (including medical radiological equipment acceptance and commissioning) requirements of this regulation, specified in Article 35 to 38 of this regulation are fulfilled by, or under the oversight of or with the documented advice of, a Medical Physicist, where the degree of involvement of the Medical Physicist is determined by the complexity of the particular use of radiation and the ensuing radiation risks; and

f. any delegation of responsibilities by a party referred to in this Article 32 is documented.

Justification of Medical Exposure

Article (33)

1. The Licensee shall ensure that a process is in place to determine that Medical Exposures are justified.

2. Generic Justification of a radiological procedure is carried out by the competent health authority in conjunction with appropriate professional bodies, and is to be reviewed from time to time, taking into account new knowledge and new technical developments.

3. The Radiological Medical Practitioner shall carry out the Justification of Medical Exposure for an individual patient, in consultation with the Referring Medical Practitioner when appropriate, taking into account, particularly when the patient is pregnant, breast feeding or a child:

   a. the appropriateness of the request;

   b. the urgency for the procedure;

   c. the characteristics of the exposure;

   d. the characteristics of the individual patient; and

   e. relevant information from previous radiological procedures.

4. The Radiological Medical Practitioner, in consultation with the Referring Medical Practitioner when appropriate, shall take into account relevant national or international guidelines in justifying the exposure of an individual patient for diagnostic, image-guided interventional or therapeutic purposes.

5. Radiological procedures performed as part of a health screening programme of asymptomatic populations are justified if the programme is approved by the Ministry of Health.

6. The Radiological Medical Practitioner, in consultation with the Referring Medical Practitioner, shall undertake specific Justification for a radiological procedure on an asymptomatic individual, intended to be performed for early detection of disease but not as part of an approved health screening programme, by following guidelines from relevant professional bodies or the health competent authority. As part of that process the individual must be informed about the estimated benefits, risks and limitations of the procedure.

Optimisation of Medical Exposures

Article (34)

1. The Licensee shall ensure that Medical Exposures are Optimised.

2. The Licensee shall ensure that use is made only of medical radiological equipment and of software that can influence the delivery of the radiation that conforms to applicable standards of the International Electrotechnical Commission (IEC) and the ISO.

3. The Radiological Medical Practitioner shall ensure, in relation to diagnostic radiological procedures and image-guided interventional procedures, in cooperation with the Medical Radiation Technologist, the Medical Physicist, and the Radiopharmacist, if appropriate, that the following are used:

    a. appropriate medical radiological equipment and software and, for nuclear medicine, also appropriate radiopharmaceuticals;

    b. appropriate techniques and parameters to deliver a patient exposure that is the minimum necessary to achieve the clinical purpose of the procedure, taking into account relevant norms of acceptable image quality established by appropriate professional bodies and any relevant Diagnostic Reference Levels.

4. The Radiological Medical Practitioner shall ensure, in relation to therapeutic radiological procedures, in cooperation with the Medical Physicist and the Medical Radiation Technologist, that for each patient the exposure of volumes other than the planning target volume is kept as low as reasonably achievable consistent with delivering the prescribed Dose to the planning target volume within the required tolerances.

5. The Radiological Medical Practitioner shall ensure, in relation to therapeutic radiological procedures involving administered radionuclides, in cooperation with the Medical Physicist, the Medical Radiation Technologist, and the Radiopharmacist, if appropriate, that for each patient the appropriate radiopharmaceutical and radioactivity are selected and administered so that the exposure is primarily localised in the organ(s) of interest, while the exposure in the rest of the body is kept as low as reasonably achievable.

6. The Licensee shall ensure that the Optimisation process considers the unique aspects of Medical Exposures involving:

   a. paediatric patients;

   b. individuals as part of a health screening programme;

   c. volunteers as part of a biomedical research project;

   d. relatively high Doses to the patient. The term 'relatively high' is intended to apply within a given context. For example, within the context of diagnostic radiology, CT procedures typically lead to doses that are relatively high compared with the usual distribution of patient doses in diagnostic radiology; similarly for image-guided interventional procedures within the context of fluoroscopy procedures. Clearly radiation oncology exposures are also included;

   e. exposure of an embryo or foetus, particularly for radiological procedures where the abdomen or pelvis of the woman who is pregnant is in the useful beam or may receive a significant Dose; and

   f. exposure of a child as a result of a breast-feeding female undergoing a radiological procedure with unsealed radionuclides or radiopharmaceuticals.

Calibration and Clinical Dosimetry

Article (35)

1. The Licensee shall make arrangements for a Medical Physicist to ensure that:

   a. all Radiation Sources used for Medical Exposure are calibrated in terms of appropriate quantities using internationally or nationally accepted protocols;

   b. calibrations are carried out at the time of Commissioning a unit prior to clinical use, after any Maintenance procedure that may have an effect on the dosimetry and at intervals approved by the Authority;

   c. prior to clinical use, calibrations of radiotherapy units are verified by independent means; and

d. the calibrations of all dosimeters, used for patient dosimetry or for the calibration of Radiation Sources, are traceable to a standards dosimetry laboratory.

Article (36)

1. The Licensee shall ensure that appropriate clinical dosimetry is performed, and documented, by or under the supervision of a Medical Physicist, using calibrated dosimeters and following internationally or nationally accepted protocols, including:

   a. for diagnostic Medical Exposures, typical patient Doses for common examinations;

   b. for image-guided interventional procedures, typical patient Doses; and

   c. for therapeutic Medical Exposures, individual patient Absorbed Doses to the tissues or organs determined relevant by the Radiological Medical Practitioner.

Article (37)

1. The Licensee shall ensure that:

   a. local Assessments, based on the measurements required by Article 36 of this regulation, are made at approved intervals for those radiological procedures for which Diagnostic Reference Levels have been established;

   b. a review is conducted to determine whether the Optimisation of protection of patients is adequate or whether corrective action is required if the typical Doses or activities for a given radiological procedure:

      - exceed the relevant Diagnostic Reference Level, or
      - fall substantially below the relevant Diagnostic Reference Level and the exposures do not provide useful diagnostic information or do not yield the expected medical benefit to the patient.

Quality Assurance

Article (38)

1. The Licensee shall establish a comprehensive programme of Quality Assurance commensurate with the risks involved for Medical Exposures with the active participation of the Medical Physicists, Radiological Medical Practitioners, Medical Radiation Technologists and, for complex nuclear medicine Facilities, Radiopharmacists.

2. The Licensee shall ensure that programme of Quality Assurance for Medical Exposures include, as appropriate to the medical radiation Facility:

   a. measurements by, or under the oversight of, a Medical Physicist of the physical parameters of medical radiological equipment:

      - at the time of acceptance and Commissioning prior to clinical use on patients, and
      - periodically thereafter, and
      - after any major Maintenance that could affect patient protection;

   b. implementation of corrective actions if measured values of the physical parameters are outside established tolerance limits,

   c. verification of the appropriate physical and clinical factors used in patient diagnosis or treatment,

   d. records of relevant procedures and results,

   e. periodic checks of the appropriate calibration and conditions of operation of dosimetry and monitoring equipment.

3. The Licensee shall ensure that there are regular and independent audits of the programme of Quality Assurance for Medical Exposure; their frequency depending on the complexity of the radiological procedures performed and the risks involved.

Protection of Women

Article (39)

1. The Licensee shall ensure that there are procedures in place to afford appropriate Radiation Protection in cases where a woman may be pregnant or is breast-feeding.

2. The Licensee shall ensure that there are signs in public places, patients' waiting rooms, cubicles and other appropriate places, and other communication methods as appropriate that inform female patients to notify hospital personnel if they are or might be pregnant. Where a female patient is scheduled to undergo a radiological procedure that involves the administration of an unsealed radionuclide or radiopharmaceutical, the signs shall inform the patient to notify hospital personnel if she is breast-feeding. Such signs have to be in all languages appropriate for the people normally served by the medical radiation Facility.

3. The Licensee shall ensure that there are procedures in place to ascertain the pregnancy status of a female of reproductive capacity before performing any radiological procedure that may give a significant Dose to the embryo or foetus, so that this information can be considered in the Justification for the radiological procedure and in its Optimisation.

4. The Licensee shall ensure that there are procedures in place to ascertain whether a female is breast-feeding before performing any radiological procedure involving the administration of an unsealed radionuclide or radiopharmaceutical that may give a significant Dose to the nursling, so that this information can be considered in the Justification for the radiological procedure and in its Optimisation.

Release of Patients following Radionuclide Therapy

Article (40)

1. The Licensee shall ensure that there are arrangements in place to ensure appropriate Radiation Protection for members of the public and for family members before a patient is released following radionuclide therapy.

2. The Radiological Medical Practitioner shall ensure that no patient who has undergone a therapeutic procedure with sealed or unsealed Radioactive Sources is released from a medical radiation Facility until it has been established by either a Medical Physicist or by the Facility's Radiation Protection Officer that:

   a. the radioactivity of Radioactive Material in the patient is such that the Doses that may be received by members of the public and family members are justified and Optimised in the individual circumstances applying; and

   b. the parent or legal guardian of the patient is provided with:

      - written instructions with a view to keeping Doses to persons in contact with or in the vicinity of the patient as low as reasonably achievable and to avoiding the spread of contamination, and

      - information on the risks of radiation effects.

Unintended or Accidental Medical Exposures

Article (41)

1. The Licensee shall ensure that all practicable measures are taken to minimise the likelihood of unintended or Accidental Medical Exposures. They shall promptly investigate any such exposure and, if appropriate, shall implement corrective measures.

2. The Licensee shall ensure that all reasonable measures are taken to minimise the likelihood of unintended or Accidental Medical Exposures arising from Design flaws and operational failures of medical radiological equipment, failures and errors of software, or as a result of human error.

3. The Licensee shall promptly investigate and notify relevant health authority of any of the following unintended or Accidental Medical Exposures:

   a. any treatment delivered to the wrong individual or the wrong tissue of the patient, or using the wrong radiopharmaceutical, or with a Dose or Dose fractionation differing substantially (above or below) from the values prescribed by the Radiological Medical Practitioner, or which may lead to unduly severe secondary effects;

   b. any diagnostic or image-guided interventional procedure which irradiates the wrong individual or the wrong tissue of the patient;

   c. any exposure for diagnostic purposes substantially greater than intended;

   d. any exposure substantially greater than intended arising from an image-guided interventional procedure;

   e. any inadvertent exposure of the foetus in the course of performing a radiological procedure; and

   f. any medical radiological equipment, software or other system failure, Accident, error, mishap or other unusual occurrence with the potential for causing a patient exposure substantially different from that intended.

4. The Licensee shall, with respect to any investigation required under Article 41(3) above:

   a. calculate or estimate the Doses received and their distribution within the patient;

   b. indicate the corrective measures required to prevent recurrence of such an unintended or Accidental Medical Exposure;

   c. implement all the corrective measures that are under their own responsibility;

   d. produce and keep as a record, as soon as possible after the investigation or as otherwise specified by the Authority, a written report which states the cause of the unintended or Accidental Medical Exposure and includes the information specified in (a) to (c), as relevant, and any other information required by the Authority; and submit this report, within 30 days, to the Authority, and to the relevant health authority if appropriate, for those unintended or Accidental Medical Exposures involving significant exposure or as otherwise required by the Authority; and

   e. inform the Referring Medical Practitioner and the patient about the unintended or Accidental Medical Exposure.

Radiological Reviews

Article (42)

1. The Licensee shall keep records and shall ensure that periodic radiological reviews are performed at a medical radiation Facility.

2. The Licensee shall ensure that periodic radiological reviews are performed by the Radiological Medical Practitioners at the medical Facility, in cooperation with the Medical Radiation Technologists and the Medical Physicists. The radiological review shall include the current practical implementation of the Radiation Protection principles of Justification and Optimisation for the radiological procedures that are being performed in the medical Facility.

3. The Licensee shall keep for five years and make available to the Authority, as required, the following records:

   a. in diagnostic radiology, necessary information to allow retrospective Dose Assessment, including the number of exposures and the duration of fluoroscopic examinations;

   b. in image-guided interventional procedures, necessary information to allow retrospective Dose Assessment, including the duration of the fluoroscopy component and the number of images acquired;

   c. in nuclear medicine, types of radiopharmaceuticals administered and their activities;

   d. in radiation oncology, a description of the planning target volume, the Dose to the centre of the planning target volume and the maximum and minimum Doses delivered to the planning target volume or alternative equivalent information on Doses to the planning target volume, the Doses to other relevant organs selected by the Radiological Medical Practitioner, the Dose fractionation, and the overall treatment time; and

   e. the exposure of volunteers in biomedical research.

4. The Licensee shall keep for five years and make available to the Authority, as required, the results of the calibrations and periodic checks of the relevant physical and clinical parameters selected during treatments.

5. The Licensee shall keep for five years and make available to the Authority, as required, the following records:

   a. any delegation of responsibilities (see Article 32(5)(f) of this regulation); and

   b. training records of personnel in Radiation Protection (see Article 27 of this regulation).

Schedule I

Table I-1 Levels for Exemption of Moderate Amounts of Material without further Consideration: Exempt Activity Concentrations and Exempt Activities of Radionuclides

Radionuclide	Activity concentration (Bq/g)	Activity Bq)	Radionuclide	Activity concentration (Bq/g)	Activity(Bq)
H-3	1×10^{6}	1×10^{9}	Sc-45	1×10^{2}	1×10^{7}
Be-7	1×10^{3}	1×10^{7}	Sc-46	1×10^{1}	1×10^{6}
Be-10	1×10^{4}	1×10^{6}	Sc-47	1×10^{2}	1×10^{6}
C-11	1×10^{1}	1×10^{6}	Sc-48	1×10^{1}	1×10^{5}
C-14	1×10^{4}	1×10^{7}	Sc-49	1×10^{3}	1×10^{5}
N-13	1×10^{2}	1×10^{9}	Ti-44	1×10^{1}	1×10^{5}
Ne-19	1×10^{2}	1×10^{9}	Ti-45	1×10^{1}	1×10^{6}
O-15	1×10^{2}	1×10^{9}	V-47	1×10^{1}	1×10^{5}
F-18	1×10^{1}	1×10^{6}	V-48	1×10^{1}	1×10^{5}
Na-22	1×10^{1}	1×10^{6}	V-49	1×10^{4}	1×10^{7}
Na-24	1×10^{1}	1×10^{5}	Cr-48	1×10^{2}	1×10^{6}
Mg-28	1×10^{1}	1×10^{5}	Cr-49	1×10^{1}	1×10^{6}
Al-26	1×10^{1}	1×10^{5}	Cr-51	1×10^{3}	1×10^{7}
Si-31	1×10^{3}	1×10^{6}	Mn-51	1×10^{1}	1×10^{5}
Si-32	1×10^{3}	1×10^{6}	Mn-52	1×10^{1}	1×10^{5}
P-32	1×10^{3}	1×10^{5}	Mn-52m	1×10^{1}	1×10^{5}
P-33	1×10^{5}	1×10^{8}	Mn-53	1×10^{4}	1×10^{9}
S-35	1×10^{5}	1×10^{8}	Mn-54	1×10^{1}	1×10^{6}
Cl-36	1×10^{4}	1×10^{6}	Mn-56	1×10^{1}	1×10^{5}
Cl-38	1×10^{1}	1×10^{5}	Fe-52	1×10^{1}	1×10^{6}
Cl-39	1×10^{1}	1×10^{5}	Fe-55	1×10^{4}	1×10^{6}
Ar-37	1×10^{6}	1×10^{8}	Fe-59	1×10^{1}	1×10^{6}
Ar-39	1×10^{7}	1×10^{4}	Fe-60	1×10^{2}	1×10^{5}
Ar-41	1×10^{2}	1×10^{9}	Co-55	1×10^{1}	1×10^{6}
K-40	1×10^{2}	1×10^{6}	Co-56	1×10^{1}	1×10^{5}
K-42	1×10^{2}	1×10^{6}	Co-57	1×10^{2}	1×10^{6}
K-43	1×10^{1}	1×10^{6}	Co-58	1×10^{1}	1×10^{6}
K-44	1×10^{1}	1×10^{5}	Co-58m	1×10^{4}	1×10^{7}
K-45	1×10^{1}	1×10^{5}	Co-60	1×10^{1}	1×10^{5}
C-41	1×10^{5}	1×10^{7}	Co-60m	1×10^{3}	1×10^{6}
Ca-45	1×10^{4}	1×10^{7}	Co-61	1×10^{2}	1×10^{6}
Ca-47	1×10^{1}	1×10^{6}	Co-62m	1×10^{1}	1×10^{5}
Sc-43	1×10^{1}	1×10^{6}	Ni-56	1×10^{1}	1×10^{6}
Sc-44	1×10^{1}	1×10^{5}	Ni-57	1×10^{1}	1×10^{6}

Radionuclide	Activity concentration (Bq/g)	Activity(Bq)	Radionuclide	Activity concentration (Bq/g)	Activity(Bq)
Ni-59	1×10^4	1×10^8	Se-70	1×10^1	1×10^6
Ni-63	1×10^5	1×10^8	Se-73	1×10^1	1×10^6
Ni-65	1×10^1	1×10^6	Se-73m	1×10^2	1×10^6
Ni-66	1×10^4	1×10^7	Se-75	1×10^2	1×10^6
Cu-60	1×10^1	1×10^5	Se-79	1×10^4	1×10^7
Cu-61	1×10^1	1×10^6	Se-81	1×10^3	1×10^6
Cu-64	1×10^2	1×10^6	Se-81m	1×10^3	1×10^7
Cu-67	1×10^2	1×10^6	Se-83	1×10^1	1×10^5
Zn-62	1×10^2	1×10^6	Br-74	1×10^1	1×10^5
Zn-63	1×10^1	1×10^5	Br-74m	1×10^1	1×10^5
Zn-65	1×10^1	1×10^6	Br-75	1×10^1	1×10^6
Zn-69	1×10^4	1×10^6	Br-76	1×10^1	1×10^5
Zn-69m	1×10^2	1×10^6	Br-77	1×10^2	1×10^6
Zn-71m	1×10^1	1×10^6	Br-80	1×10^2	1×10^5
Zn-72	1×10^2	1×10^6	Br-80m	1×10^3	1×10^7
Ga-65	1×10^1	1×10^5	Br-82	1×10^1	1×10^6
Ga-66	1×10^1	1×10^5	Br-83	1×10^3	1×10^6
Ga-67	1×10^2	1×10^6	Br-84	1×10^1	1×10^5
Ga-68	1×10^1	1×10^5	Kr-74	1×10^2	1×10^9
Ga-70	1×10^2	1×10^6	Kr-76	1×10^2	1×10^9
Ga-72	1×10^1	1×10^5	Kr-77	1×10^2	1×10^9
Ga-73	1×10^2	1×10^6	Kr-79	1×10^3	1×10^5
Ge-66	1×10^1	1×10^6	Kr-81	1×10^4	1×10^7
Ge-67	1×10^1	1×10^5	Kr-81m	1×10^3	1×10^{10}
Ge-68[a]	1×10^1	1×10^5	Kr-83m	1×10^5	1×10^{12}
Ge-69	1×10^1	1×10^6	Kr-85	1×10^5	1×10^4
Ge-71	1×10^4	1×10^8	Kr-85m	1×10^3	1×10^{10}
Ge-75	1×10^3	1×10^6	Kr-87	1×10^2	1×10^9
Ge-77	1×10^1	1×10^5	Kr-88	1×10^2	1×10^9
Ge-78	1×10^2	1×10^6	Rb-79	1×10^1	1×10^5
As-69	1×10^1	1×10^5	Rb-81	1×10^1	1×10^6
As-70	1×10^1	1×10^5	Rb-81m	1×10^3	1×10^7
As-71	1×10^1	1×10^6	Rb-82m	1×10^1	1×10^6
As-72	1×10^1	1×10^5	Rb-83[a]	1×10^2	1×10^6
As-73	1×10^3	1×10^7	Rb-84	1×10^1	1×10^6
As-74	1×10^1	1×10^6	Rb-86	1×10^2	1×10^5
As-76	1×10^2	1×10^5	Rb-87	1×10^3	1×10^7
As-77	1×10^3	1×10^6	Rb-88	1×10^2	1×10^5

Radionuclide	Activity concentration (Bq/g)	Activity(Bq)	Radionuclide	Activity concentration (Bq/g)	Activity(Bq)
Sr-80	1×10^3	1×10^7	Nb-98	1×10^1	1×10^5
Sr-81	1×10^1	1×10^5	Mo-90	1×10^1	1×10^6
Sr-82[a]	1×10^1	1×10^5	Mo-93	1×10^3	1×10^8
Sr-83	1×10^1	1×10^6	Mo-93m	1×10^1	1×10^6
Sr-85	1×10^2	1×10^6	Mo-99	1×10^2	1×10^6
Sr-85m	1×10^2	1×10^7	Mo-101	1×10^1	1×10^6
Sr-87m	1×10^2	1×10^6	Tc-93	1×10^1	1×10^6
Sr-89	1×10^3	1×10^6	Tc-93m	1×10^1	1×10^6
Sr-90[a]	1×10^2	1×10^4	Tc-94	1×10^1	1×10^6
Sr-91	1×10^1	1×10^5	Tc-94m	1×10^1	1×10^5
Sr-92	1×10^1	1×10^6	Tc-95	1×10^1	1×10^6
Y-86	1×10^1	1×10^5	Tc-95m	1×10^1	1×10^6
Y-86m	1×10^2	1×10^7	Tc-96	1×10^1	1×10^6
Y-87[a]	1×10^1	1×10^6	Tc-96m	1×10^3	1×10^7
Y-88	1×10^1	1×10^6	Tc-97	1×10^3	1×10^8
Y-90	1×10^3	1×10^5	Tc-97m	1×10^3	1×10^7
Y-90m	1×10^1	1×10^6	Tc-98	1×10^1	1×10^6
Y-91	1×10^3	1×10^6	Tc-99	1×10^4	1×10^7
Y-91m	1×10^2	1×10^6	Tc-99m	1×10^2	1×10^7
Y-92	1×10^2	1×10^5	Tc-101	1×10^2	1×10^6
Y-93	1×10^2	1×10^5	Tc-104	1×10^1	1×10^5
Y-94	1×10^1	1×10^5	Ru-94	1×10^2	1×10^6
Y-95	1×10^1	1×10^5	Ru-97	1×10^2	1×10^7
Zr-86	1×10^2	1×10^7	Ru-103	1×10^2	1×10^6
Zr-88	1×10^2	1×10^6	Ru-105	1×10^1	1×10^6
Zr-89	1×10^1	1×10^6	Ru-106[a]	1×10^2	1×10^5
Zr-93[a]	1×10^3	1×10^7	Rh-99	1×10^1	1×10^6
Zr-95	1×10^1	1×10^6	Rh-99m	1×10^1	1×10^6
Zr-97[a]	1×10^1	1×10^5	Rh-100	1×10^1	1×10^6
Nb-88	1×10^1	1×10^5	Rh-101	1×10^2	1×10^7
Nb-89 (2.03 h)	1×10^1	1×10^5	Rh-101m	1×10^2	1×10^7
Nb-89 (1.01 h)	1×10^1	1×10^5	Rh-102	1×10^1	1×10^6
Nb-90	1×10^1	1×10^5	Rh-102m	1×10^2	1×10^6
Nb-93m	1×10^4	1×10^7	Rh-103m	1×10^4	1×10^8
Nb-94	1×10^1	1×10^6	Rh-105	1×10^2	1×10^7
Nb-95	1×10^1	1×10^6	Rh-106m	1×10^1	1×10^5
Nb-95m	1×10^2	1×10^7	Rh-107	1×10^2	1×10^6
Nb-96	1×10^1	1×10^5	Pd-100	1×10^2	1×10^7
Nb-97	1×10^1	1×10^6	Pd-101	1×10^2	1×10^6

Radionuclide	Activity concentration (Bq/g)	Activity(Bq)	Radionuclide	Activity concentration (Bq/g)	Activity(Bq)
Pd-103	1×10^3	1×10^8	Sn-111	1×10^2	1×10^6
Pd-107	1×10^5	1×10^8	Sn-113	1×10^3	1×10^7
Pd-109	1×10^3	1×10^6	Sn-117m	1×10^2	1×10^6
Ag-102	1×10^1	1×10^5	Sn-119m	1×10^3	1×10^7
Ag-103	1×10^1	1×10^6	Sn-121	1×10^5	1×10^7
Ag-104	1×10^1	1×10^6	Sn-121m[a]	1×10^3	1×10^7
Ag-104m	1×10^1	1×10^6	Sn-123	1×10^3	1×10^6
Ag-105	1×10^2	1×10^6	Sn-123m	1×10^2	1×10^6
Ag-106	1×10^1	1×10^6	Sn-125	1×10^2	1×10^5
Ag-106m	1×10^1	1×10^6	Sn-126[a]	1×10^1	1×10^5
Ag-108m	1×10^1	1×10^6	Sn-127	1×10^1	1×10^6
Ag-110m	1×10^1	1×10^6	Sn-128	1×10^1	1×10^6
Ag-111	1×10^3	1×10^6	Sb-115	1×10^1	1×10^6
Ag-112	1×10^1	1×10^5	Sb-116	1×10^1	1×10^6
Ag-115	1×10^1	1×10^5	Sb-116m	1×10^1	1×10^5
Cd-104	1×10^2	1×10^7	Sb-117	1×10^2	1×10^7
Cd-107	1×10^3	1×10^7	Sb-118m	1×10^1	1×10^6
Cd-109	1×10^4	1×10^6	Sb-119	1×10^3	1×10^7
Cd-113	1×10^3	1×10^6	Sb-120 (5.76d)	1×10^1	1×10^6
Cd-113m	1×10^3	1×10^6	Sb-120 (15.89m)	1×10^2	1×10^6
Cd-115	1×10^2	1×10^6	Sb-122	1×10^2	1×10^4
Cd-115m	1×10^3	1×10^6	Sb-124	1×10^1	1×10^6
Cd-117	1×10^1	1×10^6	Sb-124m	1×10^2	1×10^6
Cd-117m	1×10^1	1×10^6	Sb-125	1×10^2	1×10^6
In-109	1×10^1	1×10^6	Sb-126	1×10^1	1×10^5
In-110 (4.9h)	1×10^1	1×10^6	Sb-126m	1×10^1	1×10^5
In-110(69.1m)	1×10^1	1×10^5	Sb-127	1×10^1	1×10^6
In-111	1×10^2	1×10^6	Sb-128(9.01h)	1×10^1	1×10^5
In-112	1×10^2	1×10^6	Sb-128 (10.4m)	1×10^1	1×10^5
In-113m	1×10^2	1×10^6	Sb-129	1×10^1	1×10^6
In-114	1×10^3	1×10^5	Sb-130	1×10^1	1×10^5
In-114m	1×10^2	1×10^6	Sb-131	1×10^1	1×10^6
In-115	1×10^3	1×10^5	Te-116	1×10^2	1×10^7
In-115m	1×10^2	1×10^6	Te-121	1×10^1	1×10^6
In-116m	1×10^1	1×10^5	Te-121m	1×10^2	1×10^6
In-117	1×10^1	1×10^6	Te-123	1×10^3	1×10^6
In-117m	1×10^2	1×10^6	Te-123m	1×10^2	1×10^7
In-119m	1×10^2	1×10^5	Te-125m	1×10^3	1×10^7
Sn-110	1×10^2	1×10^7	Te-127	1×10^3	1×10^6

Radionuclide	Activity concentration (Bq/g)	Activity (Bq)	Radionuclide	Activity concentration (Bq/g)	Activity(Bq)
Te-127m	1×10^3	1×10^7	Cs-127	1×10^2	1×10^5
Te-129	1×10^2	1×10^6	Cs-129	1×10^2	1×10^5
Te-129m	1×10^3	1×10^6	Cs-130	1×10^2	1×10^6
Te-131	1×10^2	1×10^5	Cs-131	1×10^3	1×10^6
Te-131m	1×10^1	1×10^6	Cs-132	1×10^1	1×10^5
Te-132	1×10^2	1×10^7	Cs-134m	1×10^3	1×10^5
Te-133	1×10^1	1×10^5	Cs-134	1×10^1	1×10^4
Te-133m	1×10^1	1×10^5	Cs-135	1×10^4	1×10^7
Te-134	1×10^1	1×10^6	Cs-135m	1×10^1	1×10^6
I-120	1×10^1	1×10^5	Cs-136	1×10^1	1×10^5
I-120m	1×10^1	1×10^5	Cs-137[a]	1×10^1	1×10^4
I-121	1×10^2	1×10^6	Cs-138	1×10^1	1×10^4
I-123	1×10^2	1×10^7	Ba-126	1×10^2	1×10^7
I-124	1×10^1	1×10^6	Ba-128	1×10^2	1×10^7
I-125	1×10^3	1×10^6	Ba-131	1×10^2	1×10^6
I-126	1×10^2	1×10^6	Ba-131m	1×10^2	1×10^7
I-128	1×10^2	1×10^5	Ba-133	1×10^2	1×10^6
I-129	1×10^2	1×10^5	Ba-133m	1×10^2	1×10^6
I-130	1×10^1	1×10^6	Ba-135m	1×10^2	1×10^6
I-131	1×10^2	1×10^6	Ba-137m	1×10^1	1×10^6
I-132	1×10^1	1×10^5	Ba-139	1×10^2	1×10^5
I-132m	1×10^2	1×10^6	Ba-140[a]	1×10^1	1×10^5
I-133	1×10^1	1×10^6	Ba-141	1×10^2	1×10^5
I-134	1×10^1	1×10^5	Ba-142	1×10^2	1×10^6
I-135	1×10^1	1×10^6	La-131	1×10^1	1×10^6
Xe-120	1×10^2	1×10^9	La-132	1×10^1	1×10^6
Xe-121	1×10^2	1×10^9	La-135	1×10^3	1×10^7
Xe-122[a]	1×10^2	1×10^9	La-137	1×10^3	1×10^7
Xe-123	1×10^2	1×10^9	La-138	1×10^1	1×10^6
Xe-125	1×10^3	1×10^9	La-140	1×10^1	1×10^5
Xe-127	1×10^3	1×10^5	La-141	1×10^2	1×10^5
Xe-129m	1×10^3	1×10^4	La-142	1×10^1	1×10^5
Xe-131m	1×10^4	1×10^4	La-143	1×10^2	1×10^5
Xe-133m	1×10^3	1×10^4	Ce-134	1×10^3	1×10^7
Xe-133	1×10^3	1×10^4	Ce-135	1×10^1	1×10^6
Xe-135	1×10^3	1×10^{10}	Ce-137	1×10^3	1×10^7
Xe-135m	1×10^2	1×10^9	Ce-137m	1×10^3	1×10^6
Xe-138	1×10^2	1×10^9	Ce-139	1×10^2	1×10^6
Cs-125	1×10^1	1×10^4	Ce-141	1×10^2	1×10^7

Radionuclide	Activity concentration (Bq/g)	Activity(Bq)	Radionuclide	Activity concentration (Bq/g)	Activity(Bq)
Ce-143	1×10^{2}	1×10^{6}	Sm-155	1×10^{2}	1×10^{6}
Ce-144[a]	1×10^{2}	1×10^{5}	Sm-156	1×10^{2}	1×10^{6}
Pr-136	1×10^{1}	1×10^{5}	Eu-145	1×10^{1}	1×10^{6}
Pr-137	1×10^{2}	1×10^{6}	Eu-146	1×10^{1}	1×10^{6}
Pr-138m	1×10^{1}	1×10^{6}	Eu-147	1×10^{2}	1×10^{6}
Pr-139	1×10^{2}	1×10^{7}	Eu-148	1×10^{1}	1×10^{6}
Pr-142	1×10^{2}	1×10^{5}	Eu-149	1×10^{2}	1×10^{7}
Pr-142m	1×10^{7}	1×10^{9}	Eu-150 (34.2y)	1×10^{1}	1×10^{6}
Pr-143	1×10^{4}	1×10^{6}	Eu-150 (12.6h)	1×10^{3}	1×10^{6}
Pr-144	1×10^{2}	1×10^{5}	Eu-152	1×10^{1}	1×10^{6}
Pr-145	1×10^{3}	1×10^{5}	Eu-152m	1×10^{2}	1×10^{6}
Pr-147	1×10^{1}	1×10^{5}	Eu-154	1×10^{1}	1×10^{6}
Nd-136	1×10^{2}	1×10^{6}	Eu-155	1×10^{2}	1×10^{7}
Nd-138	1×10^{3}	1×10^{7}	Eu-156	1×10^{1}	1×10^{6}
Nd-139	1×10^{2}	1×10^{6}	Eu157	1×10^{2}	1×10^{6}
Nd-139m	1×10^{1}	1×10^{6}	Eu-158	1×10^{1}	1×10^{5}
Nd-141	1×10^{2}	1×10^{7}	Gd-145	1×10^{1}	1×10^{5}
Nd-147	1×10^{2}	1×10^{6}	Gd-146[a]	1×10^{1}	1×10^{6}
Nd-149	1×10^{2}	1×10^{6}	Gd-147	1×10^{1}	1×10^{6}
Nd-151	1×10^{1}	1×10^{5}	Gd-148	1×10^{1}	1×10^{4}
Pm-141	1×10^{1}	1×10^{5}	Gd-149	1×10^{2}	1×10^{6}
Pm-143	1×10^{2}	1×10^{6}	Gd-151	1×10^{2}	1×10^{7}
Pm-144	1×10^{1}	1×10^{6}	Gd-152	1×10^{1}	1×10^{4}
Pm-145	1×10^{3}	1×10^{7}	Gd-153	1×10^{2}	1×10^{7}
Pm-146	1×10^{1}	1×10^{6}	Gd-159	1×10^{3}	1×10^{6}
Pm-147	1×10^{4}	1×10^{7}	Tb-147	1×10^{1}	1×10^{6}
Pm-148	1×10^{1}	1×10^{5}	Tb-149	1×10^{1}	1×10^{6}
Pm-148m	1×10^{1}	1×10^{6}	Tb-150	1×10^{1}	1×10^{6}
Pm-149	1×10^{3}	1×10^{6}	Tb-151	1×10^{1}	1×10^{6}
Pm-150	1×10^{1}	1×10^{5}	Tb-153	1×10^{2}	1×10^{7}
Pm-151	1×10^{2}	1×10^{6}	Tb-154	1×10^{1}	1×10^{6}
Sm-141	1×10^{1}	1×10^{5}	Tb-155	1×10^{2}	1×10^{7}
Sm-141m	1×10^{1}	1×10^{6}	Tb-156	1×10^{1}	1×10^{6}
Sm-142	1×10^{2}	1×10^{7}	Tb-156m(24.4h)	1×10^{3}	1×10^{7}
Sm-145	1×10^{2}	1×10^{7}	Tb-156m (5h)	1×10^{4}	1×10^{7}
Sm-146	1×10^{1}	1×10^{5}	Tb-157	1×10^{4}	1×10^{7}
Sm-147	1×10^{1}	1×10^{4}	Tb-158	1×10^{1}	1×10^{6}
Sm-151	1×10^{4}	1×10^{8}	Tb-160	1×10^{1}	1×10^{6}
Sm-153	1×10^{2}	1×10^{6}	Tb-161	1×10^{3}	1×10^{6}

Radionuclide	Activity concentration (Bq/g)	Activity (Bq)	Radionuclide	Activity concentration (Bq/g)	Activity(Bq)
Dy-155	1×10^{1}	1×10^{6}	Lu-172	1×10^{1}	1×10^{6}
Dy-157	1×10^{2}	1×10^{6}	Lu-173	1×10^{2}	1×10^{7}
Dy-159	1×10^{3}	1×10^{7}	Lu-174	1×10^{2}	1×10^{7}
Dy-165	1×10^{3}	1×10^{6}	Lu-174m	1×10^{2}	1×10^{7}
Dy-166	1×10^{3}	1×10^{6}	Lu-176	1×10^{2}	1×10^{6}
Ho-155	1×10^{2}	1×10^{6}	Lu-176m	1×10^{3}	1×10^{6}
Ho-157	1×10^{2}	1×10^{6}	Lu-177	1×10^{3}	1×10^{7}
Ho-159	1×10^{2}	1×10^{6}	Lu-177m	1×10^{1}	1×10^{6}
Ho-161	1×10^{2}	1×10^{7}	Lu-178	1×10^{2}	1×10^{5}
Ho-162	1×10^{2}	1×10^{7}	Lu-178m	1×10^{1}	1×10^{5}
Ho-162m	1×10^{1}	1×10^{6}	Lu-179	1×10^{3}	1×10^{6}
Ho-164	1×10^{3}	1×10^{6}	Hf-170	1×10^{2}	1×10^{6}
Ho-164m	1×10^{3}	1×10^{7}	Hf-172[a]	1×10^{1}	1×10^{6}
Ho-166	1×10^{3}	1×10^{5}	Hf-173	1×10^{2}	1×10^{6}
Ho-166m	1×10^{1}	1×10^{6}	Hf-175	1×10^{2}	1×10^{6}
Ho-167	1×10^{2}	1×10^{6}	Hf-177m	1×10^{1}	1×10^{5}
Er-161	1×10^{1}	1×10^{6}	Hf-178m	1×10^{1}	1×10^{6}
Er-165	1×10^{3}	1×10^{7}	Hf-179m	1×10^{1}	1×10^{6}
Er-169	1×10^{4}	1×10^{7}	Hf-180m	1×10^{1}	1×10^{6}
Er-171	1×10^{2}	1×10^{6}	Hf-181	1×10^{1}	1×10^{6}
Er-172	1×10^{2}	1×10^{6}	Hf-182	1×10^{2}	1×10^{6}
Tm-162	1×10^{1}	1×10^{6}	Hf-182m	1×10^{1}	1×10^{6}
Tm-166	1×10^{1}	1×10^{6}	Hf-183	1×10^{1}	1×10^{6}
Tm-167	1×10^{2}	1×10^{6}	Hf-184	1×10^{2}	1×10^{6}
Tm-170	1×10^{3}	1×10^{6}	Ta-172	1×10^{1}	1×10^{6}
Tm-171	1×10^{4}	1×10^{8}	Ta -173	1×10^{1}	1×10^{6}
Tm-172	1×10^{2}	1×10^{6}	Ta-174	1×10^{1}	1×10^{6}
Tm-173	1×10^{2}	1×10^{6}	Ta-175	1×10^{1}	1×10^{6}
Tm-175	1×10^{1}	1×10^{6}	Ta-176	1×10^{1}	1×10^{6}
Yb-162	1×10^{2}	1×10^{7}	Ta-177	1×10^{2}	1×10^{7}
Yb-166	1×10^{2}	1×10^{7}	Ta-178	1×10^{1}	1×10^{6}
Yb-167	1×10^{2}	1×10^{6}	Ta-179	1×10^{3}	1×10^{7}
Yb-169	1×10^{2}	1×10^{7}	Ta-180	1×10^{1}	1×10^{6}
Yb-175	1×10^{3}	1×10^{7}	Ta-180m	1×10^{3}	1×10^{7}
Yb-177	1×10^{2}	1×10^{6}	Ta-182	1×10^{1}	1×10^{4}
Yb-178	1×10^{3}	1×10^{6}	Ta-182m	1×10^{2}	1×10^{6}
Lu-169	1×10^{1}	1×10^{6}	Ta-183	1×10^{2}	1×10^{6}
Lu-170	1×10^{1}	1×10^{6}	Ta-184	1×10^{1}	1×10^{6}
Lu-171	1×10^{1}	1×10^{6}	Ta-185	1×10^{2}	1×10^{5}

Radionuclide	Activity concentration (Bq/g)	Activity (Bq)	Radionuclide	Activity concentration (Bq/g)	Activity(Bq)
Ta-186	1×10^{1}	1×10^{5}	Ir-190	1×10^{1}	1×10^{6}
W-176	1×10^{2}	1×10^{6}	Ir-190m (3.1h)	1×10^{1}	1×10^{6}
W-177	1×10^{1}	1×10^{6}	Ir-190m (1.2h)	1×10^{4}	1×10^{7}
W-178[a]	1×10^{1}	1×10^{6}	Ir-192	1×10^{1}	1×10^{4}
W-179	1×10^{2}	1×10^{7}	Ir-192m	1×10^{2}	1×10^{7}
W-181	1×10^{3}	1×10^{7}	Ir-193m	1×10^{4}	1×10^{7}
W-185	1×10^{4}	1×10^{7}	Ir-194	1×10^{2}	1×10^{5}
W-187	1×10^{2}	1×10^{6}	Ir-194m	1×10^{1}	1×10^{6}
W-188a	1×10^{2}	1×10^{5}	Ir-195	1×10^{2}	1×10^{6}
Re-177	1×10^{1}	1×10^{6}	Ir-195m	1×10^{2}	1×10^{6}
Re-178	1×10^{1}	1×10^{6}	Pt-186	1×10^{1}	1×10^{6}
Re-181	1×10^{1}	1×10^{6}	Pt-188[a]	1×10^{1}	1×10^{6}
Re-182 (64h)	1×10^{1}	1×10^{6}	Pt-189	1×10^{2}	1×10^{6}
Re-182(12.7h)	1×10^{1}	1×10^{6}	Pt-191	1×10^{2}	1×10^{6}
Re-184	1×10^{1}	1×10^{6}	Pt-193	1×10^{4}	1×10^{7}
Re-184m	1×10^{2}	1×10^{6}	Pt-193m	1×10^{3}	1×10^{7}
Re-186	1×10^{3}	1×10^{6}	Pt-195m	1×10^{2}	1×10^{6}
Re-186m	1×10^{3}	1×10^{7}	Pt-197	1×10^{3}	1×10^{6}
Re-187	1×10^{6}	1×10^{9}	Pt-197m	1×10^{2}	1×10^{6}
Re-188	1×10^{2}	1×10^{5}	Pt-199	1×10^{2}	1×10^{6}
Re-188m	1×10^{2}	1×10^{7}	Pt-200	1×10^{2}	1×10^{6}
Re-189[a]	1×10^{2}	1×10^{6}	Au-193	1×10^{2}	1×10^{7}
Os-180	1×10^{2}	1×10^{7}	Au-194	1×10^{1}	1×10^{6}
Os-181	1×10^{1}	1×10^{6}	Au-195	1×10^{2}	1×10^{7}
Oc-182	1×10^{2}	1×10^{6}	Au-198	1×10^{2}	1×10^{6}
Os-185	1×10^{1}	1×10^{6}	Au-198m	1×10^{1}	1×10^{6}
Os-189m	1×10^{4}	1×10^{7}	Au-199	1×10^{2}	1×10^{6}
Os-191	1×10^{2}	1×10^{7}	Au-200	1×10^{2}	1×10^{5}
Os-191m	1×10^{3}	1×10^{7}	Au-200m	1×10^{1}	1×10^{6}
Os-193	1×10^{2}	1×10^{6}	Au-201	1×10^{2}	1×10^{6}
Os-194[a]	1×10^{2}	1×10^{5}	Hg-193	1×10^{2}	1×10^{6}
Ir-182	1×10^{1}	1×10^{5}	Hg-193m	1×10^{1}	1×10^{6}
Ir-184	1×10^{1}	1×10^{6}	Hg-194[a]	1×10^{1}	1×10^{6}
Ir-185	1×10^{1}	1×10^{6}	Hg-195	1×10^{2}	1×10^{6}
Ir-186 (15.8h)	1×10^{1}	1×10^{6}	Hg-195m[a]	1×10^{2}	1×10^{6}
Ir-186 (1.75h)	1×10^{1}	1×10^{6}	Hg-197	1×10^{2}	1×10^{7}
Ir-187	1×10^{2}	1×10^{6}	Hg-197m	1×10^{2}	1×10^{6}
Ir-188	1×10^{1}	1×10^{6}	Hg-199m	1×10^{2}	1×10^{6}
Ir-189a	1×10^{2}	1×10^{7}	Hg-203	1×10^{2}	1×10^{5}

Radionuclide	Activity concentration (Bq/g)	Activity (Bq)	Radionuclide	Activity concentration (Bq/g)	Activity(Bq)
Tl-194	1×10^{1}	1×10^{6}	Po-206	1×10^{1}	1×10^{6}
Tl-194m	1×10^{1}	1×10^{6}	Po-207	1×10^{1}	1×10^{6}
Tl-195	1×10^{1}	1×10^{6}	Po-208	1×10^{1}	1×10^{4}
Tl-197	1×10^{2}	1×10^{6}	Po-209	1×10^{1}	1×10^{4}
Tl-198	1×10^{1}	1×10^{6}	Po-210	1×10^{1}	1×10^{4}
Tl-198m	1×10^{1}	1×10^{6}	At-207	1×10^{1}	1×10^{6}
Tl-199	1×10^{2}	1×10^{6}	At-211	1×10^{3}	1×10^{7}
Tl-200	1×10^{1}	1×10^{6}	Fr-222	1×10^{3}	1×10^{5}
Tl-201	1×10^{2}	1×10^{6}	Fr-223	1×10^{2}	1×10^{6}
Tl-202	1×10^{2}	1×10^{6}	Rn-220[a]	1×10^{4}	1×10^{7}
Tl-204	1×10^{4}	1×10^{4}	Rn-222[a]	1×10^{1}	1×10^{8}
Pb-195m	1×10^{1}	1×10^{6}	Ra-223[a]	1×10^{2}	1×10^{5}
Pb-198	1×10^{2}	1×10^{6}	Ra-224[a]	1×10^{1}	1×10^{5}
Pb-199	1×10^{1}	1×10^{6}	Ra-225	1×10^{2}	1×10^{5}
Pb-200	1×10^{2}	1×10^{6}	Ra-226[a]	1×10^{1}	1×10^{4}
Pb-201	1×10^{1}	1×10^{6}	Ra-227	1×10^{2}	1×10^{6}
Pb-202	1×10^{3}	1×10^{6}	Ra-228[a]	1×10^{1}	1×10^{5}
Pb-202m	1×10^{1}	1×10^{6}	Ac-224	1×10^{2}	1×10^{6}
Pb-203	1×10^{2}	1×10^{6}	Ac-225[a]	1×10^{1}	1×10^{4}
Pb-205	1×10^{4}	1×10^{7}	Ac-226	1×10^{2}	1×10^{5}
Pb-209	1×10^{5}	1×10^{6}	Ac-227[a]	1×10^{-1}	1×10^{3}
Pb-210[a]	1×10^{1}	1×10^{4}	Ac-228	1×10^{1}	1×10^{6}
Pb-211	1×10^{2}	1×10^{6}	Th-226[a]	1×10^{3}	1×10^{7}
Pb-212[a]	1×10^{1}	1×10^{5}	Th-227	1×10^{1}	1×10^{4}
Pb-214	1×10^{2}	1×10^{6}	Th-228[a]	1×10^{0}	1×10^{4}
Bi-200	1×10^{1}	1×10^{6}	Th-229[a]	1×10^{0}	1×10^{3}
Bi-201	1×10^{1}	1×10^{6}	Th-230	1×10^{0}	1×10^{4}
Bi-202	1×10^{1}	1×10^{6}	Th-231	1×10^{3}	1×10^{7}
Bi-203	1×10^{1}	1×10^{6}	Th-232	1×10^{1}	1×10^{4}
Bi-205	1×10^{1}	1×10^{6}	Th-234[a]	1×10^{3}	1×10^{5}
Bi-206	1×10^{1}	1×10^{5}	Pa-227	1×10^{1}	1×10^{6}
Bi-207	1×10^{1}	1×10^{6}	Pa-228	1×10^{1}	1×10^{6}
Bi-210	1×10^{3}	1×10^{6}	Pa-230	1×10^{1}	1×10^{6}
Bi-210m[a]	1×10^{1}	1×10^{5}	Pa-231	1×10^{0}	1×10^{3}
Bi-212[a]	1×10^{1}	1×10^{5}	Pa-232	1×10^{1}	1×10^{6}
Bi-213	1×10^{2}	1×10^{6}	Pa-233	1×10^{2}	1×10^{7}
Bi-214	1×10^{1}	1×10^{5}	Pa-234	1×10^{1}	1×10^{6}
Po-203	1×10^{1}	1×10^{6}	U-230[a]	1×10^{1}	1×10^{5}
Po-205	1×10^{1}	1×10^{6}	U-231	1×10^{2}	1×10^{7}

Radionuclide	Activity concentration (Bq/g)	Activity(Bq)	Radionuclide	Activity concentration (Bq/g)	Activity(Bq)
U-232[a]	1×10^{0}	1×10^{3}	Am-242m[a]	1×10^{0}	1×10^{4}
U-233	1×10^{1}	1×10^{4}	Am-243[a]	1×10^{0}	1×10^{3}
U-234	1×10^{1}	1×10^{4}	Am-244	1×10^{1}	1×10^{6}
U-235a	1×10^{1}	1×10^{4}	Am-244m	1×10^{4}	1×10^{7}
U-236	1×10^{1}	1×10^{4}	Am-245	1×10^{3}	1×10^{6}
U-237	1×10^{2}	1×10^{6}	Am-246	1×10^{1}	1×10^{5}
U-238[a]	1×10^{1}	1×10^{4}	Am-246m	1×10^{1}	1×10^{6}
U-239	1×10^{2}	1×10^{6}	Cm-238	1×10^{2}	1×10^{7}
U-240	1×10^{3}	1×10^{7}	Cm-240	1×10^{2}	1×10^{5}
U-240[a]	1×10^{1}	1×10^{6}	Cm-241	1×10^{2}	1×10^{6}
Np-232	1×10^{1}	1×10^{6}	Cm-242	1×10^{2}	1×10^{5}
Np-233	1×10^{2}	1×10^{7}	Cm-243	1×10^{0}	1×10^{4}
Np-234	1×10^{1}	1×10^{6}	Cm-244	1×10^{1}	1×10^{4}
Np-235	1×10^{3}	1×10^{7}	Cm-245	1×10^{0}	1×10^{3}
Np-236 $1.15.10^{5}$y)	1×10^{2}	1×10^{5}	Cm-246	1×10^{0}	1×10^{3}
Np-236 (22.5h)	1×10^{3}	1×10^{7}	Cm-247	1×10^{0}	1×10^{4}
Np-237[a]	1×10^{0}	1×10^{3}	Cm-248	1×10^{0}	1×10^{3}
Np-238	1×10^{2}	1×10^{6}	Cm-249	1×10^{3}	1×10^{6}
Np-239	1×10^{2}	1×10^{7}	Cm-250	1×10^{-1}	1×10^{3}
Np-240	1×10^{1}	1×10^{6}	Bk-245	1×10^{2}	1×10^{6}
Pu-234	1×10^{2}	1×10^{7}	Bk-246	1×10^{1}	1×10^{6}
Pu-235	1×10^{2}	1×10^{7}	Bk-247	1×10^{0}	1×10^{4}
Pu-236	1×10^{1}	1×10^{4}	Bk-249	1×10^{3}	1×10^{6}
Pu-237	1×10^{3}	1×10^{7}	Bk-250	1×10^{1}	1×10^{6}
Pu-238	1×10^{0}	1×10^{4}	Cf-244	1×10^{4}	1×10^{7}
Pu-239	1×10^{0}	1×10^{4}	Cf-246	1×10^{3}	1×10^{6}
Pu-240	1×10^{0}	1×10^{3}	Cf-248	1×10^{1}	1×10^{4}
Pu-241	1×10^{2}	1×10^{5}	Cf-249	1×10^{0}	1×10^{3}
Pu-242	1×10^{0}	1×10^{4}	Cf-250	1×10^{1}	1×10^{4}
Pu-243	1×10^{3}	1×10^{7}	Cf-251	1×10^{0}	1×10^{3}
Pu-244	1×10^{0}	1×10^{4}	Cf-252	1×10^{1}	1×10^{4}
Pu-245	1×10^{2}	1×10^{6}	Cf-253	1×10^{2}	1×10^{5}
Pu-246	1×10^{2}	1×10^{6}	Cf-254	1×10^{0}	1×10^{3}
Am-237	1×10^{2}	1×10^{6}	Es-250	1×10^{2}	1×10^{6}
Am-238	1×10^{1}	1×10^{6}	Es-251	1×10^{2}	1×10^{7}
Am-239	1×10^{2}	1×10^{6}	Es-253	1×10^{2}	1×10^{5}
Am-240	1×10^{1}	1×10^{6}	Es-254	1×10^{1}	1×10^{4}
Am-241	1×10^{0}	1×10^{4}	Es-254m	1×10^{2}	1×10^{6}
Am-242	1×10^{3}	1×10^{6}	Fm-252	1×10^{3}	1×10^{6}

Radionuclide	Activity concentration (Bq/g)	Activity (Bq)	Radionuclide	Activity concentration (Bq/g)	Activity (Bq)
Fm-253	1×10^2	1×10^6	Md-258	1×10^2	1×10^5
Fm-254	1×10^4	1×10^7			
Fm-255	1×10^3	1×10^6			
Fm-257	1×10^1	1×10^5			
Md-257	1×10^2	1×10^7			

a = Parent radionuclides, and their progeny whose Dose contributions are taken into account in the Dose calculation (thus requiring only the exemption level of the parent radionuclide to be considered), are listed in the following:

Ge-68	Ga-68	Rn-220	Po-216
Rb-83	Kr-83m	Rn-222	Po-218, Pb-214, Bi-214,
Sr-82	Rb-82		Po-214
Sr-90	Y-90	Ra-223	Rn-219, Po-215, Pb-211, Bi-211,
Y-87	Sr-87m		Tl-207
Zr-93 Zr-97 Ru-106	Nb-93m Nb-97 Rh-106	Ra-224 Ra-226	Rn-220, Po-216, Pb-212, Bi-212, Tl-208 (0.36), Po-212 (0.64) Rn-222, Po-218, Pb-214, Bi-214, Po-214, Pb-210, Bi-210, Po-210
Ag-108m	Ag-108	Ra-228	Ac-228
Sn-121m	Sn-121 (0.776)	Ac-225	Fr-221, At-217, Bi-213,
Sn-126	Sb-126m		Po-213 (0.978), Tl-209 (0.0216),
Xe-122	I-122		Pb-209 (0.978)
Cs-137	Ba-137m	Ac-227	Fr-223 (0.0138)
Ba-140	La-140	Th-226	Ra-222, Rn-218, Po-214
Ce-134	La-134	Th-228	Ra-224, Rn-220, Po-216, Pb-212,
Ce-144	Pr-144		Bi-212,Tl-208 (0.36), Po-212 (0.64)
Gd-146Hf-172W-178 W-188 Re-189 Ir-189	Eu-146 Lu-172 Ta-178 Re-188 Os-189m (0.241) Os-189m	Th-229 Th-234 U-230 U-232	Ra-225, Ac-225, Fr-221, At-217, Bi-213, Po-213, Pb-209 Pa-234m Th-226, Ra-222, Rn-218, Po-214 Th-228, Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Tl-208 (0.36), Po-212 (0.64)
Pt-188	Ir-188	U-235	Th-231
Hg-194	Au-194	U-238	Th-234, Pa-234m
Hg-195m	Hg-195 (0.542)	U-240	Np-240m

Pb-210	Bi-210, Po-210	Np-237	Pa-233
Pb-212	Bi-212, Tl-208 (0.36),	Am-242m	Am-242
Bi-210m	Po-212 (0.64) Tl-206	Am-243	Np-239
Bi-212	Tl-208 (0.36), Po-212 (0.64)		

Table I-2 – Levels for Clearance and for Exemption of Bulk Amounts of Material without further Consideration : Activity Concentrations of Radionuclides of Artificial Origin

Radionuclide	Activity concentration (Bq/g)	Radionuclide	Activity concentration (Bq/g)	Radionuclide	Activity concentration (Bq/g)
H-3	100	Co-58	1	Y-93	100
Be-7	10	Co-58m	10 000	Zr-93	10
C-14	1	Co-60	0.1	Zr-95a	1
F-18	10	Co-60m	1000	Zr-97a	10
Na-22	0.1	Co-61	100	Nb-93m	10
Na-24	1	Co-62m	10	Nb-94	0.1
Si-31	1000	Ni-59	100	Nb-95	1
P-32	1000	Ni-63	100	Nb-97[a]	10
P-33	1000	Ni-65	10	Nb-98	10
S-35	100	Cu-64	100	Mo-90	10
Cl-36	1	Zn-65	0.1	Mo-93	10
Cl-38	10	Zn-69	1000	Mo-99[a]	10
K-42	100	Zn-69m[a]	10	Mo-101[a]	10
K-43	10	Ga-72	10	Tc-96	1
Ca-45	100	Ge-71	10 000	Tc-96m	1000
Ca-47	10	As-73	1000	Tc-97	10
Sc-46	0.1	As-74	10	Tc-97m	100
Sc-47	100	As-76	10	Tc-99	1
Sc-48	1	As-77	1000	Tc-99m	100
V-48	1	Se-75	1	Ru-97	10
Cr-51	100	Br-82	1	Ru-103[a]	1
Mn-51	10	Rb-86	100	Ru-105[a]	10
Mn-52	1	Sr-85	1	Ru-106[a]	0.1
Mn-52m	10	Sr-85m	100	Rh-103m	10 000
Mn-53	100	Sr-87m	100	Rh-105	100
Mn-54	0.1	Sr-89	1000	Pd-103[a]	1000
Mn-56	10	Sr-90a	1	Pd-109[a]	100
Fe-52[a]	10	Sr-91a	10	Ag-105	1
Fe-55	1000	Sr-92	10	Ag-110m[a]	0.1
Fe-59	1	Y-90	1000	Ag-111	100
Co-55	10	Y-91	100	Cd-109[a]	1
Co-56	0.1	Y-91m	100	Cd-115[a]	10
Co-57	1	Y-92	100	Cd-115m[a]	100

Radionuclide	Activity concentration (Bq/g)	Radionuclide	Activity concentration (Bq/g)	Radionuclide	Activity concentration (Bq/g)
In-111	10	Cs-138	10	Os-185	1
In-113m	100	Ba-131	10	Os-191	100
In-114m[a]	10	Ba-140	1	Os-191m	1000
In-115m	100	La-140	1	Os-193	100
Sn-113[a]	1	Ce-139	1	Ir-190	1
Sn-125	10	Ce-141	100	Ir-192	1
Sb-122	10	Ce-143	10	Ir-194	100
Sb-124	1	Ce-144	10	Pt-191	10
Sb-125a	0.1	Pr-142	100	Pt-193m	1000
Te-123m	1	Pr-143	1000	Pt-197	1000
Te-125m	1000	Nd-147	100	Pt-197m	100
Te-127	1000	Nd-149	100	Au-198	10
Te-127m[a]	10	Pm-147	1000	Au-199	100
Te-129	100	Pm-149	1000	Hg-197	100
Te-129m[a]	10	Sm-151	1000	Hg-197m	100
Te-131	100	Sm-153	100	Hg-203	10
Te-131m[a]	10	Eu-152	0.1	Tl-200	10
Te-132[a]	1	Eu-152m	100	Tl-201	100
Te-133	10	Eu-154	0.1	Tl-202	10
Te-133m	10	Eu-155	1	Tl-204	1
Te-134	10	Gd-153	10	Pb-203	10
I-123	100	Gd-159	100	Bi-206	1
I-125	100	Tb-160	1	Bi-207	0.1
I-126	10	Dy-165	1000	Po-203	10
I-129	0.01	Dy-166	100	Po-205	10
I-130	10	Ho-166	100	Po-207	10
I-131	10	Er-169	1000	At-211	1000
I-132	10	Er-171	100	Ra-225	10
I-133	10	Tm-170	100	Ra-227	100
I-134	10	Tm-171	1000	Th-226	1000
I-135	10	Yb-175	100	Th-229	0.1
Cs-129	10	Lu-177	100	Pa-230	10
Cs-131	1000	Hf-181	1	Pa-233	10
Cs-132	10	Ta-182	0.1	U-230	10
Cs-134	0.1	W-181	10	U-231[a]	100
Cs-134m	1000	W-185	1000	U-232[a]	0.1
Cs-135	100	W-187	10	U-233	1
Cs-136	1	Re-186	1000	U-236	10
Cs-137a	0.1	Re-188	100	U-237	100

Radionuclide	Activity concentration (Bq/g)	Radionuclide	Activity concentration (Bq/g)	Radionuclide	Activity concentration (Bq/g)
U-239	100	Pu-244a	0.1	Cf-249	0.1
U-240a	100	Am-241	0.1	Cf-250	1
Np-237a	1	Am-242	1000	Cf-251	0.1
Np-239	100	Am-242m[a]	0.1	Cf-252	1
Np-240	10	Am-243[a]	0.1	Cf-253	100
Pu-234	100	Cm-242	10	Cf-254	1
Pu-235	100	Cm-243	1	Es-253	100
Pu-236	1	Cm-244	1	Es-254[a]	0.1
Pu-237	100	Cm-245	0.1	Es-254m[a]	10
Pu-238	0.1	Cm-246	0.1	Fm-254	10 000
Pu-239	0.1	Cm-247[a]	0.1	Fm-255	100
Pu-240	0.1	Cm-248	0.1		
Pu-241	10	Bk-249	100		
Pu-242	0.1	Cf-246	1000		
Pu-243	1000	Cf-248	1		

a = Parent radionuclides, and their progeny whose Dose contributions are taken into account in the Dose calculation (thus requiring only the exemption level of the parent radionuclide to be considered), are listed in the following:

Fe-52	Mn-52m	Sn-113	In-113m
Zn-69m	Zn-69	Sb-125	Te-125m
Sr-90	Y-90	Te-127m	Te-127
Sr-91	Y-91m	Te-129m	Te-129
Zr-95	Nb-95	Te-131m	Te-131
Zr-97	Nb-97m, Nb-97	Te132	I-132
Nb-97	Nb-97m	Cs-137	Ba-137m
Mo-99	Tc-99m	Ce-144	Pr-144, Pr-144m
Mo-101Ru-103	Tc-101 Rh-103m	U-232sec	Th-228, Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Tl-208
Ru-105	Rh-105m	U-240	Np-240m, Np-240
Ru-106	Rh-106	Np237	Pa-233
Pd-103	Rh-103m	Pu-244	U-240, Np-240m, Np-240

Pd-109 Ag-110m Cd-109 Cd-115	Ag-109m Ag-110 Ag-109m In-115m	Am-242mAm-243 Cm-247 Es-254	Np-238 Np-239 Pu-243 Bk-250
Cd-115m	In-115m	Es-254m	Fm-254
In-114m	In-114		

Table I-3: Levels for Clearance of material: Activity Concentrations of Radionuclides of Natural Origin

Radionuclide	Activity concentration (Bq/g)
K-40	10
Each radionuclide in the uranium and thorium decay chains	1