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PART II

Statutory Notifications (S. R. O.)

GOVERNMENT OF PAKISTAN

PAKISTAN NUCLEAR REGULATORY AUTHORITY

NOTIFICATION

Islamabad, the 17th October, 2020

S.R.O. 1477(I)/2020.—In exercise of the powers conferred by Section 16(2)(a) read with Section 56 of the Pakistan Nuclear Regulatory Authority Ordinance, 2001, the Pakistan Nuclear Regulatory Authority is pleased to make and promulgate the following regulations:

1. **Short Title, Extent, Applicability and Commencement**.—(1) These regulations may be called the "Regulations on Radiation Protection - (PAK/904) (Rev.1)".

(2) These regulations extend to the whole of Pakistan.

(3) These regulations shall be applicable for the protection against risks of ionizing radiation.

(4) These regulations shall come into force at once.

Price: Rs. 100.00

[6661(2020)/Ex. Gaz.]

2. **Definitions**.—In these regulations, unless there is anything repugnant in the subject or context,

(a) *"absorbed dose"* means 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 dm is the mass of matter in the volume element;

(b) *"accident"* means any unintended event, including operating errors, equipment failures or other mishaps, the consequences or potential consequences of which are not negligible from the point of view of protection and safety;

(c) *"activity"* means the quantity A for an amount of radionuclide in a given energy state at a given time, defined as:

$$A(t) = \frac{dN}{dt}$$

where dN is the expectation value of the number of spontaneous nuclear transformations from the given energy state in the time interval dt;

(d) *"annual dose"* means the dose from external exposure in a year plus the committed dose from intakes of radionuclides in that year;

(e) *"applicant"* means a person who has applied to the Authority for a license or an authorization;

(f) *"assessment"* means the process, and the result, of analyzing systematically and evaluating the hazards associated with sources and practices, and associated protection and safety measures;

(g) *"carers and comforters"* means persons who willingly and voluntarily help (other than in their occupation) in the care, support and comfort of patients undergoing radiological procedures for medical diagnosis or medical treatment;

(h) *"closure"* means the administrative and technical actions directed at a disposal facility at the end of its operating lifetime;

(i) *"clearance"* means removal of regulatory control by the Authority from radioactive material or radioactive objects within authorized facilities and activities;

(j) *"committed dose"* means the lifetime dose expected to result from an intake;

(k) *"confinement"* means the prevention or control of releases of radioactive material to the environment in operation or in accidents;

(l) *"consumer product"* means a device or manufactured item into which radionuclides have deliberately been incorporated or produced by activation, or which generates ionizing radiation, and which can be sold or made available to members of the public without special surveillance or regulatory control after sale;

(m) *"containment"* means the methods or physical structures designed to prevent or control the release and the dispersion of radioactive substances;

(n) *"contamination"* means the radioactive substances on surfaces, or within solids, liquids or gases (including the human body), where their presence is unintended or undesirable, or the process giving rise to their presence in such places;

(o) *"controlled area"* means a defined area in which specific protection measures and safety provisions are required or may be required for controlling exposures or preventing the spread of contamination in normal working conditions, and preventing or limiting the extent of potential exposures;

(p) *"decontamination"* means the complete or partial removal of contamination by a deliberate physical, chemical or biological process;

(q) *"defence in depth"* means a hierarchical deployment of different levels of equipment and procedures in order to maintain the effectiveness of physical barriers placed between a radiation source or radioactive material and workers, members of the public or the environment, in operational states and, for some barriers, in accident conditions;

(r) *"diagnostic reference level"* means a level used in medical imaging to indicate whether, in routine conditions, the dose to the patient or the amount of radiopharmaceuticals administered in a specified

radiological procedure for medical imaging is unusually high or unusually low for that procedure;

(s) *"disposal"* means an emplacement of waste in an appropriate facility without the intention of retrieval;

(t) *"dose"* means a measure of the energy deposited by radiation in a target;

(u) *"dose constraint"* means a prospective and source related value of individual dose that is used in planned exposure situations as a parameter for the optimization of protection and safety for the source, and that serves as a boundary in defining the range of options in optimization;

(v) *"dose limit"* means the value of the effective dose or the equivalent dose to individuals in planned exposure situations that is not to be exceeded;

(w) *"effective dose, E"* means the quantity E, defined as a summation of the tissue or organ equivalent doses, each multiplied by the appropriate tissue weighting factor:

$$E = \sum_{T} w_T . H_T$$

where H_T is the equivalent dose in tissue or organ T and w_T is the tissue weighting factor for tissue or organ T. From the definition of equivalent dose, it follows that:

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

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

(x) *"emergency exposure situation"* means a situation of exposure that arises as a result of an accident, a malicious act or other unexpected event, and requires prompt action in order to avoid or reduce adverse consequences;

(y) *"equivalent dose, H_T"* means the quantity $H_{T,R}$ defined as:

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

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

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

(z) *"employer"* means a person or organization with recognized responsibilities, commitments and duties towards a worker in the employment of the person or organization by virtue of a mutually agreed relationship;

(aa) *"exemption"* means the determination by the Authority that a source or practice need not be subject to some or all aspects of regulatory control on the basis that the exposure and the potential exposure due to the source or practice are too small to warrant the application of those aspects or that this is the optimum option for protection irrespective of the actual level of the doses or risks;

(bb) *"exemption level"* means a value, established by the Authority and expressed in terms of activity concentration, total activity, dose rate or radiation energy, at or below which a source of radiation need not be subject to some or all aspects of regulatory control;

(cc) *"existing exposure situation"* means a situation of exposure that already exists when a decision on the need for control needs to be taken;

(dd) *"exposure"* means a state or condition of being subject to irradiation;

(ee) *"external exposure"* means an exposure to radiation from a source outside the body;

(ff) *"internal exposure"* means an exposure to radiation from a source within the body;

(gg) *"facilities and activities"* means a general term encompassing nuclear facilities, uses of all sources of ionizing radiation, all radioactive waste management activities, transport of radioactive material and any other practice or circumstances in which people

may be subject to exposure to radiation from naturally occurring or artificial sources;

(i) "facilities" include nuclear facilities; irradiation installations; some mining and raw material processing facilities such as uranium mines; radioactive waste management facilities; and any other places where radioactive material is produced, processed, used, handled, stored or disposed of — or where radiation generators are installed — on such a scale that consideration of protection and safety is required.

(ii) "activities" include the production, use, import and export of radiation sources for industrial, research and medical purposes; the transport of radioactive material; the decommissioning of facilities; radioactive waste management activities such as the discharge of effluents; and some aspects of the remediation of sites affected by residues from past activities.

(hh) *"health professional"* means an individual who has been accredited through appropriate national procedures to practice a profession related to health (e.g. nursing, medical physics, radiation and nuclear medical technology, radiopharmacy, occupational health);

(ii) *"health screening program"* means a program in which health tests or medical examinations are performed for the purpose of early detection of disease;

(jj) *"incident"* means any unintended event, including operating errors, equipment failures, initiating events, accident precursors, near misses or other mishaps, or unauthorized act, malicious or non-malicious, the consequences or potential consequences of which are not negligible from the point of view of protection and safety;

(kk) *"intake"* means the act or process of taking radionuclides into the body by inhalation or ingestion or through the skin;

(ll) *"intervention"* means any action intended to reduce or avert exposure or the likelihood of exposure to sources which are not part of a controlled practice or which are out of control as a consequence of an accident;

(mm) *"investigation level"* means a value of a quantity such as effective dose, intake or contamination per unit area or volume at or above which an investigation would be conducted;

(nn) *"licensee"* means the holder of a valid license issued by the Authority;

(oo) *"limit"* means the value of a quantity used in certain specified activities or circumstances that must not be exceeded;

(pp) *"medical exposure"* means exposure incurred by patients for the purposes of their own medical or dental diagnosis (diagnostic exposure) or medical treatment (therapeutic exposure); by carers and comforters; and by volunteers subject to exposure as part of a program of biomedical research;

(qq) *"medical professional"* means an individual who:

(i) has been accredited through Pakistan Medical and Dental Council (PM&DC) as a registered medical practitioner or registered dental practitioner; and

(ii) fulfills the requirements of training and experience as approved by the Authority.

(rr) *"member of the public"* means for purposes of protection and safety, any individual in a general sense, any individual in the population except, for protection and safety purposes, when subject to occupational or medical exposure. For the purpose of verifying compliance with the annual dose limit for public exposure, this is the representative person;

(ss) *"monitoring"* means the measurement of dose, dose rate or activity for reasons relating to the assessment or control of exposure to radiation or radioactive substances, and the interpretation of the results;

(tt) *"natural background"* means the doses, dose rates or activity concentrations associated with natural sources, or any other sources in the environment that are not amenable to control;

(uu) *"occupational exposure"* means exposure of workers incurred in the course of their work;

(vv) *"optimization"* means the process of determining what level of protection and safety would result in the magnitude of individual doses, the number of individuals (workers and members of the public) subject to exposure and the likelihood of exposure being as low as reasonably achievable, economic and social factors being

taken into account (ALARA). For medical exposure, the management of the radiation dose to the patient commensurate with the medical purpose;

(ww) *"planned exposure situation"* means the situation of exposure that arises from the planned operation of a source or from a planned activity that results in an exposure due to a source;

(xx) *"potential exposure"* means exposure that is not expected to be delivered with certainty but that may result from an anticipated operational occurrence or accident at a source or owing to an event or sequence of events of a probabilistic nature, including equipment failures and operating errors;

(yy) *"practice"* means any human activity that introduces additional sources of exposure or exposure pathways or extends exposure to additional people or modifies the network of exposure pathways from existing sources, so as to increase the exposure or the likelihood of exposure of people or the number of people exposed;

(zz) *"protection and safety"* means the protection of people against exposure to ionizing radiation or exposure due to radioactive material and the safety of sources, including the means for achieving this, and the means for preventing accidents and for mitigating the consequences of accidents if they do occur;

(aaa) *"protective action"* means an action for the purposes of avoiding or reducing doses that might otherwise be received in an emergency exposure situation or an existing exposure situation;

(bbb) *"public exposure"* means exposure incurred by members of the public due to sources in planned exposure situations, emergency exposure situations and existing exposure situations, excluding any occupational exposure or medical exposure;

(ccc) *"quality assurance"* means planned and systematic actions necessary to provide adequate confidence that an item, process or service will satisfy specified requirements for quality;

(ddd) *"radiation"* means ionizing radiation capable of producing ion pairs in biological material;

(eee) *"radiation generator"* means 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;

(fff) *"radioactive source"* means a source containing radioactive material that is used as a source of radiation;

(ggg) *"Radiation Protection Officer (RPO)"* means an individual technically competent in radiation protection matters relevant for a given type of practice who is designated by the licensee to oversee the application of the regulatory requirements;

(hhh) *"reference level"* means for an emergency exposure situation or an existing exposure situation, the level of dose, risk or activity concentration above which it is not appropriate to plan to allow exposures to occur and below which optimization of protection and safety would continue to be implemented;

(iii) *"representative person"* means an individual receiving a dose that is representative of the doses to the more highly exposed individuals in the population;

(jjj) *"safety culture"* means the assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, protection and safety issues receive the attention warranted by their significance;

(kkk) *"sealed source"* means radioactive material that is permanently sealed in a capsule or closely bonded and in a solid form;

(lll) *"security"* means measures to prevent unauthorized access or damage to, and loss, theft or unauthorized transfer of radioactive sources or radioactive material;

(mmm) *"source"* means anything that may cause radiation exposure, such as by emitting ionizing radiation or by releasing radioactive substances or material, and can be treated as a single entity for protection and safety purposes;

(nnn) *"supervised area"* means a defined area not designated a controlled area but for which occupational exposure conditions are kept under review, even though specific protection measures and safety provisions are not normally needed;

(ooo) *"unsealed source"* means a radioactive source in which the radioactive material is neither permanently sealed in a capsule nor closely bonded and in a solid form; and

(ppp) *"worker"* means any individual who works, whether full time, part time or temporarily, for an employer and who has recognized rights and duties in relation to occupational radiation protection.

3. **Scope**.—(1) These regulations establish the requirements for protection against risks arising from ionizing radiation which includes gamma rays, X-rays and particles such as alpha, beta, neutrons, protons, and heavier ions. Protection from the effects of non-ionizing radiation is outside the scope of these regulations.

(2) These regulations shall apply to the following facilities and activities:

(a) Acquisition, design, manufacture, construction, installation or operation of any device that contains radioactive material or produce ionizing radiation including consumer products, sealed or unsealed radioactive sources and radiation generators;

(b) Establishment of installations and facilities which contain radioactive material or devices which produce ionizing radiation including irradiation facilities, nuclear installations and radioactive waste management facilities;

(c) Exploration, leasing, mining, milling and installations for processing of radioactive ores;

(d) Acquisition, selling, buying, handling, import, export, use, transport, conversion, enrichment, production, storage, processing, reprocessing, fabrication and disposal of radioactive material or nuclear substance; and

(e) Any other source of ionizing radiation or practice involving ionizing radiation as the Authority may specify, by notification in the official Gazette.

4. **Interpretation**.—The decision of the Chairman PNRA regarding interpretation of any word or phrase of these regulations shall be final and binding.

5. **Exclusions**.—(1) The following exposures are excluded from the requirements of these regulations:

(a) Exposures from natural radioactivity;

(b) Exposures from cosmic radiation at the surface of the earth; and

(c) Exposures from any other sources that are essentially unamenable to control as may be determined by the Authority.

6. **Non-Compliance**.—(1) In the event of a breach of any relevant requirement of these regulations, the licensee shall:

(a) Inform the Authority immediately (within twenty four (24) hours);

(b) Investigate the breach and its causes, circumstances and consequences;

(c) Take appropriate action to remedy the circumstances and to prevent recurrence of similar situations;

(d) Submit report to the Authority, as a matter of priority, on the causes of the breach, its circumstances and consequences, and on the corrective or preventive actions taken or to be taken; and

(e) Take whatever other actions that are necessary as required under these regulations.

MANAGEMENT REQUIREMENTS

7. **Management for Protection and Safety**.—(1) The licensee shall have the prime responsibility for protection and safety and shall establish, and implement management system to ensure and enhance protection and safety at the highest level, commensurate with the complexity of associated radiation risk.

(2) The licensee shall establish necessary safety and security interface to ensure that they do not adversely affect each other and that, to the degree possible, they are mutually supportive.

8. **Safety Culture**.—The licensee shall establish and maintain a safety culture by means of an effective management system and a demonstrated commitment to protection and safety on the part of senior management.

9. **Human Factor**.—(1) The licensee shall ensure that all personnel on whom protection and safety depend are appropriately trained and qualified so that they understand their responsibilities and perform their duties according to defined procedures, and are periodically retrained or re-qualified as appropriate.

(2) The licensee, in cooperation with suppliers as appropriate, shall follow sound ergonomic principles in designing of equipment and preparing operating procedures, in order to facilitate the safe use of equipment and minimize the contribution of human errors leading to accidents or incidents.

(3) The licensee shall provide appropriate equipment, safety systems and procedures to:

(a) Reduce, as far as practicable, the possibility of human errors or inadvertent actions leading to the exposure of any person;

(b) Provide means to detect human errors and correct or compensate them; and

(c) Facilitate protective actions and corrective actions in the event of failures of safety systems or failures of measures for protection and safety.

10. **Designation of Radiation Protection Officer (RPO)**.—The licensee shall designate an RPO fulfilling the qualification criteria and training period given in Schedule I of these regulations.

11. **Designation of Professionals**.—(1) The licensee shall designate professionals fulfilling the qualification criteria given in Schedule II of these regulations.

(2) The licensee shall prepare and implement training and retraining program for professionals. The contents of training shall be according to Schedule III of these regulations.

12. **Exemption**.—(1) Practices or sources within practices may be exempted from the requirements of these regulations provided that they comply with the exemption criteria given in Schedule IV of these regulations.

(2) Exemption shall not be granted for practices deemed unjustified.

13. **Clearance**.—The licensee may apply for the clearance of radioactive sources within licensed practices from further compliance with the requirements of these regulations provided that they comply with the exemption criteria given in Schedule IV of these regulations.

PLANNED EXPOSURE SITUATIONS

General Requirements

14. **Responsibilities of Licensee in Planned Exposure Situations.**—(1) The licensee shall be responsible for establishing and implementing the technical

and organizational measures that are needed for ensuring protection and safety for the practices and sources for which he is licensed and for compliance with all applicable requirements of these regulations.

(2) The licensee shall not carry out any safety significant modification unless specifically authorized by the Authority.

(3) The licensee shall ensure that only qualified and designated workers are permitted to undertake and fulfill assignments and tasks related to protection and safety.

(4) The licensee shall:

(a) Perform safety assessment for the sources for which he is licensed and also perform radiological environmental impact assessments, if required by the Authority and keep it up to date;

(b) Establish arrangements for the periodic review of the overall effectiveness of the measures for protection and safety and the application of lessons learned from experience; and

(c) Ensure that adequate maintenance, testing and servicing is carried out as necessary so that sources remain capable of fulfilling their design requirements for protection and safety throughout their lifetime.

(5) The licensee shall ensure that sealed sources are categorized in accordance with Schedule V of these regulations.

(6) The licensee shall develop, maintain and update inventory of sealed sources and submit it to the Authority on quarterly basis for category-1, biannually for remaining categories of sealed sources and annually for radiation generators.

(7) The licensee shall promptly, but not later than twenty four (24) hours, notify the Authority regarding lost or theft of a radioactive source or radiation generator.

(8) The licensee shall ensure that radioactive sources are properly locked when not in use and disposed of when no further use is foreseen in future.

15. **Justification of Practices**.—(1) No practice shall be authorized unless it produces overall benefit to individuals to be exposed or to the society to offset the radiation harm that it might cause, taking into account social, economic and other relevant factors.

(2) The following practices shall deem to be not justified:

(a) Practices, except for justified practices involving medical exposure, that result in an increase in activity, by the deliberate addition of radioactive substances or by activation, in food, feed, beverages, cosmetics or any other commodity or product intended for ingestion, inhalation or percutaneous intake by, or application to, a person;

(b) Practices involving the frivolous use of radiation or radioactive substances in commodities or in consumer products such as toys and personal jewellery or adornments, which result in an increase in activity, by the deliberate addition of radioactive substances or by activation;

(c) Human imaging using radiation that is performed as a form of art or for publicity purposes; and

(d) Any other practice so determined by the Authority.

(3) Human imaging using radiation for the following purpose shall not be justified unless authorized by the Authority:

(a) Occupational, legal or health insurance purposes, and is undertaken without reference to clinical indication;

(b) Theft detection purposes;

(c) Detection of hidden objects for anti-smuggling purposes; and

(d) Detection of concealed objects that can be used for criminal acts that pose a national security threat.

(4) If in exceptional circumstances, the justification of such human imaging is to be considered, the requirements of Regulation 23 of these regulations shall apply. Such human imaging shall not be carried out without obtaining prior authorization from the Authority.

16. **Optimization of Protection and Safety**.—(1) The licensee shall ensure that protection and safety is optimized, in order that the magnitude of individual doses, except for therapeutic medical exposures, the number of people exposed and the likelihood of incurring exposures all be kept as low as reasonably achievable (ALARA), economic and social factors being taken into account, within the restriction that the dose to individuals delivered by the source be subject to dose constraints. The licensee shall use, to the extent practicable,

procedures and engineering controls based upon sound radiation safety principles to achieve this objective.

(2) For occupational exposure and public exposure, the licensee shall ensure that all relevant factors are taken into account in a coherent way for optimization of protection and safety.

(3) For occupational exposure and public exposure, the licensee shall ensure, as appropriate, that dose constraints are used in the optimization of protection and safety for any particular source within a practice.

17. **Dose Constraints**.—(1) For occupational exposure, the dose constraints shall be established by the licensee for the purpose of optimization of protection and safety.

(2) For public exposure, where a source can release radioactive substances to the environment, the dose constraints shall be established by the licensee and approved by the Authority.

18. **Dose Limits**.—The licensee shall ensure that exposure of individuals shall be restricted so that neither the effective dose nor the equivalent dose to relevant organs or tissues, caused by the possible combination of exposures from different licensed practices, exceeds any relevant dose limit specified in Schedule VI of these regulations.

19. **Monitoring for Verification of Compliance**.—(1) The licensee shall ensure that:

(a) Monitoring and measurements of the parameters are performed as necessary for verification of compliance with the requirements of these regulations;

(b) Suitable equipment is provided and procedures for verification are implemented; and

(c) Equipment is properly maintained, tested and calibrated at appropriate intervals with reference to standards traceable to national or international standards.

(2) Records shall be maintained by the licensee of the results of monitoring and verification of compliance as required by the Authority, including records of the tests and calibrations carried out in accordance with requirements of these regulations.

(3) The results of monitoring and verification of compliance shall be made available to the Authority as required.

20. **Prevention and Mitigation of Accidents**.—(1) The licensee shall ensure that the siting, location, design, manufacture, construction, assembly, commissioning, operation, maintenance and decommissioning (or closure) of facilities or parts thereof are based on good engineering practices.

(2) The licensee shall ensure that a multilayer (defence in depth) system of provisions for protection and safety is applied to sources such that a failure at one layer is compensated for or corrected by subsequent layers. Such defence in depth shall be applied for the purposes of:

(a) Preventing accidents;

(b) Mitigating the consequences of any accident that do occur; and

(c) Restoring the sources to safe conditions after any such accident.

(3) The licensee shall ensure that structures, systems and components, including software, that are related to protection and safety for facilities and activities are designed, constructed, commissioned, operated and maintained so as to prevent accidents as far as reasonably practicable.

(4) The licensee shall prepare an emergency plan for protection of the people and the environment.

21. **Investigation and Operating Experience Feedback**.—(1) The licensee shall ensure that information on both normal operation and abnormal conditions that are significant for protection and safety including events giving rise to doses exceeding relevant dose limits is provided to the Authority and relevant parties, as specified by the Authority.

(2) The licensee shall conduct an investigation in the event that:

(a) A quantity or operating parameter relating 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 condition occurs that has the potential for causing a quantity to exceed any relevant limit or operating restriction.

(3) The licensee shall conduct an investigation and inform the Authority as soon as practicable, but not later than twenty four (24) hours after

discovery, of an event and shall prepare a written record of its causes, or suspected causes, including a verification or determination of any doses received or committed and recommendations for preventing the recurrence of the event and the occurrence of similar events.

(4) The licensee shall submit a written report to the Authority within sixty (60) days of any formal investigation relating to events, including exposures giving rise to doses exceeding relevant dose limits.

22. **Manufacturing or Supply of Radiation Generators and Radioactive Sources**.—(1) The licensee being manufacturer or supplier of radiation generators and radioactive sources shall supply well designed, well manufactured and well constructed radiation generators or radioactive sources and devices in which the radiation generators or radioactive sources are used that:

(a) Provide protection and safety in accordance with the requirements of these regulations;

(b) Meet engineering, performance and functional specifications;

(c) Meet quality standards commensurate with the significance for protection and safety of components including software; and

(d) Provide clear displays, gauges and instructions on operating consoles in the appropriate language understandable to users.

(2) The manufacturer or supplier as deemed necessary shall:

(a) Ensure that radiation generators and radioactive sources are tested to demonstrate compliance with the relevant specifications;

(b) Make information available to users both in Urdu and English language, on the proper installation and use of radiation generators or radioactive sources and on its associated risks, including performance specifications, instructions for operation and maintenance and instructions for protection and safety; and

(c) Ensure that the protection provided by shielding and by other protective devices is optimized.

(3) The manufacturer of a radioactive source or a device containing a radioactive source shall ensure that the source itself and its container are marked with the radiation symbols which are visibly and firmly affixed.

23. **Human Imaging using Radiation for Purposes other than Medical Diagnosis, Medical Treatment or Biomedical Research**.—(1) Any radiological examination, for occupational, legal or health insurance purposes, undertaken without reference to clinical indications shall not be performed unless the specific type of examination is justified by a medical professional.

(2) For the inspection imaging devices in which radiation is used to expose persons for the purpose of detection of concealed weapons, contraband or other objects on or within the body, the licensee shall apply the requirements for public exposure in planned exposure situations and in particular, shall ensure that optimization of protection and safety is subject to dose constraints for public exposure.

(3) The licensee shall ensure that all individuals who are to undergo procedures with inspection imaging devices in which radiation is used are informed of the possibility of requesting the use of an alternative inspection technique that does not use ionizing radiation, where available.

Occupational Exposure

24. **Responsibilities of Licensee for Protection of Workers**.—(1) The licensee shall ensure, for all workers engaged in activities in which they are subject to occupational exposure, that:

(a) Occupational exposure dose limits specified in Schedule VI of these regulations are not exceeded;

(b) Protection and safety is optimized in accordance with the requirements of these regulations;

(c) Policies, procedures and organizational arrangements for occupational protection and safety are established to implement the relevant requirements of these regulations with priority given to the design and technical measures for controlling occupational exposure and resulting decisions on measures to be adopted for this purpose are recorded and made available to relevant parties including workers where appropriate, as specified by the Authority;

(d) Suitable and adequate facilities for protection and safety are provided, including personal protective equipment and radiation monitoring equipment for controlling occupational exposure, and arrangements are made for their proper use, calibration, testing and maintenance;

(e) Health surveillance is provided as per Schedule VII of these regulations;

(f) Necessary conditions are provided to promote a safety culture;

(g) Suitable and adequate human resources, appropriate training and retraining in protection and safety are provided;

(h) Provision of instruction on radiation protection and safety in local language; and

(i) Records are maintained in accordance with the requirements of these regulations.

(2) The licensee shall ensure that workers under their responsibility who are exposed to radiation from sources, other than natural sources, that are not directly related to or required by their work receive the same level of protection as if they were members of the public.

(3) The licensee shall ensure that workers are informed of their obligations and responsibilities for their own protection, the protection of others against radiation and the safety of sources. In particular, the licensee shall ensure that workers:

(a) Follow applicable rules and procedures for protection and safety;

(b) Properly use the monitoring devices and the protective equipment and clothing provided;

(c) Provide such information on their past and present work that is significant for ensuring protection and safety for themselves and others;

(d) Abstain from any willful action that could put themselves or others in situations that contravene the requirements of these regulations;

(e) Accept such information, instruction and training of protection and safety which enables them to perform their duties in accordance with the requirements of these regulations; and

(f) Promptly report to the licensee under established non-conformance procedure, any circumstances that could adversely affect safety conditions or the requirements of these regulations.

(4) The licensee shall record any report received from a worker that identifies any circumstances that could affect safety conditions or compliance with the requirements of these regulations and shall take appropriate remedial action.

(5) The licensee shall ensure that calibration services for radiation monitors or equipment shall be taken from authorized service providers.

(6) If workers, belong to employer who is not licensee, are to be engaged in work that involves or could involve a source which is not under the control of their employer, the licensee responsible for the source as appropriate shall:

(a) Obtain from the employer, as a pre-condition for engagement of such workers, information on their previous occupational exposure history and other information as may be necessary to provide protection and safety in compliance with these regulations;

(b) Provide such workers with protective measures and safety provisions which are at least as good as those provided for employees of the licensee;

(c) Make assessments of the doses received by the workers;

(d) Clearly allocate and document the responsibilities of the employer for protection and safety; and

(e) Make dosimetric and other appropriate information available to the employer for the purpose of demonstrating that the level of protection provided to such workers is compatible with the requirements of these regulations.

25. **Radiation Protection Program**.—The licensee shall prepare and submit radiation protection program to the Authority for approval. The program shall be reviewed periodically and revised accordingly, if required.

26. **Classification of Areas**.—(1) Controlled Area: (a) The licensee shall assess and designate an area as controlled area where there is a likelihood of receiving an effective dose greater than 6 mSv in a year or an equivalent dose greater than three tenths (3/10) of any relevant dose limit specified in Schedule VI of these regulations or in which specific protective measures or safety provisions are or could be required for:

(i) Controlling exposures or preventing the spread of contamination during normal working conditions; and

(ii) Preventing or limiting the extent of potential exposures in anticipated operational occurrences and accidental conditions.

(b) In defining the boundaries of any controlled area, the licensees shall take account of the magnitude of the exposures expected in normal operation, the likelihood and magnitude of exposures in anticipated operational occurrences and in accident conditions and the type and extent of the procedures required for protection and safety;

(c) The licensee shall:

(i) Delineate controlled areas by physical means or where this is not reasonably practicable, by some other suitable means;

(ii) Delineate an appropriate controlled area by means that are appropriate under the prevailing circumstances and specify exposure times, where a source is brought into operation or energized only intermittently or is moved from place to place;

(iii) Display internationally recognized warning symbols and appropriate instructions at access points and other appropriate locations within controlled areas;

(iv) Establish occupational protection and safety measures, including as appropriate physical measures to control the spread of contamination;

(v) Establish local rules and procedures that are appropriate for controlled areas;

(vi) Restrict access to controlled areas by means of administrative procedures, such as the use of work permits, and by physical barriers, which could include locks or interlocks; the degree of restriction being commensurate with the magnitude and likelihood of the expected exposures;

(vii) Provide, as appropriate, at entrances of controlled area:

(a) Personal protective equipment;

(b) Equipment for individual monitoring and workplace monitoring; and

(c) Suitable storage for personal clothing.

(viii) Provide, as appropriate, at exits of controlled area:

(a) Equipment for monitoring for contamination of skin and clothing;

(b) Equipment for monitoring for contamination of any objects or material being removed from the area;

(c) Washing or showering facilities and other personal decontamination facilities; and

(d) Suitable storage for contaminated personal protective equipment.

(ix) Provide appropriate information, instruction and training for workers working in controlled areas.

(2) Supervised Areas: (a) The licensee shall assess and designate an area as a supervised area not already designated as a controlled area but where there is a likelihood of receiving an effective dose greater than 1 mSv in a year or an equivalent dose greater than one tenth of any relevant dose limit specified in Schedule VI of these regulations or where occupational exposure conditions need to be kept under review even though specific protection measures and safety provisions are not normally needed; and

(b) The licensee shall delineate and identify the supervised areas by appropriate means, taking into account the nature and extent of radiation hazards in those areas and display signs, as appropriate, at access points.

(3) The licensee shall periodically review conditions to determine the possible need to revise the protection measures or safety provisions, including the boundaries of controlled and supervised areas.

27. **Local Rules, Procedures and Supervision**.—(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;

(b) Include in these rules and procedures the values of any relevant investigation level and the procedure to be followed in the event that any such value is exceeded;

(c) Ensure that any work involving occupational exposure be adequately supervised and take all reasonable steps to ensure that the local rules, procedures, protective measures and safety provisions are observed; and

(d) Ensure that local rules and procedures and the measures for protection and safety are known to those workers to whom they apply and to other persons who may be affected by them.

28. **Personal Protective Equipment**.—(1) The licensee shall minimize the need for relying on administrative controls and personal protective equipment for protection and safety during normal operations by providing appropriate well engineered controls.

(2) The licensee shall:

(a) Ensure that workers are provided with suitable and adequate personal protective equipment, including as appropriate:

(i) Protective clothing;

(ii) Protective respiratory equipment; and

(iii) Protective aprons, gloves and organ shields.

(b) Ensure that 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

(c) Take into account the following factors when assigning personal protective equipment for a given task:

(i) Medical fitness to sustain possible extra physical effort while using the protective equipment; and

(ii) Additional work time or inconvenience or additional non-radiological risks associated with the use of the protective equipment.

29. **Assessment of Occupational Exposure**.—(1) The licensee shall:

(a) Make arrangements for the assessment of occupational exposure of workers and shall ensure that adequate arrangements are made with appropriate dosimetry services under an adequate management system;

(b) Ensure that dosimetry services are availed from an authorized dosimetry service provider;

(c) Ensure that individual monitoring is undertaken for any worker who works in controlled area;

(d) Ensure that workers who could be exposed to radioactive contamination, are identified and shall arrange for appropriate monitoring to assess the intake of radioactive substances and the committed doses;

(e) Submit monitoring program to the Authority, which ensures that the requirements with regard to occupational exposure in planned exposure situations are fulfilled; and

(f) Submit periodic reports to the Authority on occupational exposure.

30. **Workplace Monitoring**.—(1) The licensee shall make arrangements to establish, maintain and review the workplace monitoring commensurate with the nature of and the risks associated with the sources under the supervision of an RPO or health physicist.

(2) The licensee shall keep appropriate records of the findings of workplace monitoring for a minimum period of five (05) years, which shall be made available to workers.

31. **Records of Occupational Exposure**.—(1) The licensee shall maintain records of exposure for each worker for whom assessment of occupational exposure is required. Such worker exposure records shall include information on:

(a) General nature of the work resulting in exposure, the doses and intakes and the data upon which the dose assessments are based;

(b) Periods of employment with different licensees, if any, and the corresponding doses and intakes in each period of employment; and

(c) Doses or intakes due to emergency interventions or accidents, which shall be distinguished from doses and intakes received during work in normal condition.

(2) The licensee shall:

(a) Provide access to workers of their exposure records;

(b) Submit exposure records of workers to the Authority as and when required; and

(c) Facilitate the provision of copies of workers' exposure records to new employers when workers change employment.

(3) Records of occupational exposure for each worker shall be maintained during and after the workers' working life, at least until the former worker attains or would have attained the age of seventy five (75) years, and for not less than thirty (30) years after cessation of the work in which the worker was subject to occupational exposure.

(4) If the licensee intends to cease the activities in which workers are subject to occupational exposure, prior to termination of authorization, he shall submit workers' exposure records to the Authority.

32. **Workers' Health Surveillance**.—(1) The licensee, in accordance with Schedule VII of these regulations, shall make arrangements for appropriate health surveillance based on general principles of occupational health and to assess the initial and continuous fitness of workers working in the controlled area for their intended tasks.

(2) The licensee shall maintain all records of health surveillance of its workers.

33. **Medical Surveillance for Abnormal Situations**.—(1) Where deemed appropriate, the licensee shall ensure that in case of radiation accident, adequate medical facilities and staff are available for the administration of first aid and for carrying out external decontamination of the affected individuals without any delay.

(2) The adequacy of such facilities shall be regularly reviewed by the licensee.

(3) The licensee shall make necessary arrangements that in case of radiation injuries, affected individuals are immediately transferred to designated hospitals for the treatment of such injuries.

34. **Information, Instruction and Training**.—(1) The licensee shall:

(a) Inform its workers about the health risks due to their occupational exposure and provide instructions and training on protection and safety;

(b) Provide appropriate information, instruction, training and retraining to the individuals of other organizations who could be affected during response in an emergency situation;

(c) Provide female workers who are liable to enter controlled areas or supervised areas with appropriate information on:

(i) The risk to the embryo or fetus due to exposure of a pregnant woman;

(ii) The importance of notifying as soon as she suspects that she is pregnant or she is breast feeding; and

(iii) The risk to infant ingesting radioactive substances through breast feeding.

(d) Keep training record.

35. **Conditions of Service**.—The licensee shall not offer special compensatory arrangements or preferential treatment with respect to salary or special insurance coverage, working hours, length of vacation, additional holidays or retirement benefits to the workers as substitutes for the provision of proper protection and safety measures to ensure compliance with the requirements of these regulations.

36. **Special Arrangements for Protection and Safety for Female Workers and for Individuals Under Eighteen (18) Years of Age Undergoing Training**.—(1) Once a female worker has notified the licensee that she is pregnant or she is breast feeding, the licensee shall not consider the notification of pregnancy or breast feeding a reason to exclude a female worker from work.

(2) The licensee shall adapt the working conditions in respect of occupational exposure so as to ensure that the embryo or fetus or breastfed infant is afforded the same broad level of protection which is required for members of the public, as is specified in Schedule VI of these regulations.

(3) The licensee shall ensure that no individual under the age of sixteen (16) years is or could be subject to occupational exposure.

(4) The licensee shall ensure that no individual under the age of eighteen (18) years is allowed to work in a controlled area unless supervised by a worker and only for the purpose of the training and studies and the corresponding dose limits shall not exceed as specified in Schedule VI of these regulations.

Public Exposure

37. **Responsibilities of Licensee Specific to Public Exposure**.—(1) The licensee shall apply the requirements of these regulations to any public exposure delivered by a practice or source for which he is responsible.

(2) In applying the principle of optimization of protection and safety in the design, planning, operation and decommissioning of a source (or for closure and the post-closure period for waste disposal facilities), the licensee shall take into account the:

(a) Possible changes in any conditions that could affect exposure to members of the public;

(b) Good practice in the operation of similar sources or the conduct of similar practices;

(c) Possible buildup and accumulation in the environment of radioactive substances from discharges during the lifetime of the source; and

(d) Uncertainties in the assessment of doses.

(3) The licensee shall establish, implement and maintain:

(a) Protection and safety policies, procedures and organizational arrangements for control of public exposure;

(b) Measures for ensuring:

(i) Optimization of the protection, subject to constraints as may be appropriate, of representative person whose exposure is attributable to such sources in accordance with the authorization;

(ii) The limitation of normal exposure of the representative person, which is attributable to such sources, in order that the total exposure is not higher than the dose limits for members of the public as specified in Schedule VI of these regulations; and

(iii) Safety of such sources, in order that the likelihood of public exposures is controlled in accordance with the requirements of these regulations.

(c) Appropriate protection and safety training, and periodic retraining, to the personnel having functions relevant to the protection of the public;

(d) Appropriate monitoring equipment and surveillance programs to assess public exposure;

(e) Adequate records of the surveillance and monitoring; and

(f) Emergency plans, emergency procedures and emergency arrangements, in accordance with the nature and magnitude of the radiation risks associated with the sources.

38. **Control of Visitors**.—(1) The licensee shall:

(a) Ensure that adequate control over entry of visitors to a controlled or supervised area is maintained;

(b) Apply relevant requirements of these regulations in respect of public exposure for visitors to a controlled or supervised area;

(c) Ensure that visitors are accompanied by an experienced radiation worker in controlled area; and

(d) Provide adequate information and instruction to visitors before they enter a controlled or supervised area.

39. **External Exposure and Contamination in Areas Accessible to Members of the Public**.—(1) If a source can give rise to external exposure to members of the public, the licensee shall ensure that:

(a) The floor plans and arrangements of equipment for all new installations utilizing such sources, as well as all significant modifications to existing installations, are subject, as appropriate, to review and approval by the Authority prior to commissioning; and

(b) Shielding and other measures for protection and safety, including access control, are provided as appropriate for restricting public exposure.

(2) The licensee shall ensure, as appropriate, that:

(a) Specific provisions for confinement are established for the design and operation of a source that could cause the spread of contamination in areas that are accessible to members of the public; and

(b) Measures for protection and safety are implemented for restricting public exposure due to contamination.

40. **Monitoring and Reporting of Public Exposure**.—(1) The licensee shall:

(a) Prepare and submit environmental monitoring program for approval by the Authority;

(b) Keep appropriate record of results of the program and estimated doses to members of the public;

(c) Report a summary of the monitoring results to the Authority on yearly basis or such shorter intervals as approved by the Authority and promptly inform the Authority of any abnormal results which lead or could lead to an increase in public exposure; and

(d) Establish and maintain capability to conduct monitoring in an emergency situation.

41. **Consumer Products**.—(1) Consumer products capable of causing exposure to radiation shall not be supplied to members of the public unless:

(a) Such exposure is excluded from the requirements of these regulations; or

(b) Such products meet the exemption requirements, as specified in Schedule IV of these regulations, or have otherwise been exempted by the Authority; or

(c) Such products are authorized by the Authority for use by members of the public.

(2) Providers of consumer products shall:

(a) Comply with the conditions of the authorization to provide consumer products to the public;

(b) Ensure that consumer products comply with the requirements of these regulations; and

(c) Plan for appropriate arrangements for the servicing, maintenance, recycling or disposal of consumer products.

(3) The design and manufacture of consumer products, with regard to features that could affect exposure during normal handling, transport and use, as well as in the event of mishandling, misuse, accident or disposal, shall be subject to the optimization of protection and safety. In this regard, designers, manufacturers and other providers of consumer products shall take into account the following:

(a) Various radionuclides that could be used in consumer products and their radiation types, energies, activities and half-lives;

(b) Chemical and physical forms of the radionuclides that could be used in consumer products and their significance for protection and safety in normal and abnormal conditions;

(c) Containment and shielding of radioactive substances in consumer products and access to these radioactive substances in normal and abnormal conditions;

(d) Need for servicing or repair of consumer products and ways in which this could be done; and

(e) Relevant experience with similar consumer products.

(4) Persons who import consumer products for sale and distribution as exempted products shall ensure that:

(a) Legible labels are visibly and firmly affixed to a visible surface of each consumer product and its package, written in Urdu and English language, that:

(i) The product contains radioactive material and identifies the radionuclides and their activities;

(ii) The sale of the product to the public has been authorized by the Authority; and

(iii) Provides information on required or recommended options for recycling or disposal.

(b) Basic information and instructions on the precautions of use and disposal of the product, written in Urdu and English language, are made available with the product.

(5) Providers of consumer products shall provide clear and appropriate information and instructions with each consumer product regarding:

(a) Its correct installation, use and maintenance;

(b) Servicing and repair;

(c) Radionuclides and their activities at a specified date;

(d) Dose rates in normal operation and during servicing and repair; and

(e) Required or recommended options for recycling or disposal.

(6) Providers of consumer products shall provide the consumer product retailers with appropriate information on safety and instructions on their transport and storage.

Medical Exposure

42. **Responsibilities of Licensee Specific to Medical Exposure**.—(1) The licensee shall ensure that:

(a) No patient undergoes a radiological procedure unless prescribed by a medical professional or it is part of an approved health screening program;

(b) The patient or the patient's legal authorized representative has been informed as appropriate of the expected benefits of the radiological procedure as well as the radiation risks;

(c) Medical professionals are responsible for ensuring overall patient protection and safety in the prescription of, and during the delivery of, medical exposure;

(d) Medical and health professionals are available as needed and have appropriate qualification and training to discharge assigned tasks in the conduct of radiological procedures;

(e) For radiological procedures requirements of these regulations for calibration, dosimetry and quality assurance, including the acceptance and commissioning of medical radiological equipment are conducted by or under the supervision of a medical physicist;

(f) The exposure of individuals incurred knowingly while voluntarily helping (other than in their occupation) in the care, support or comfort of patients are constrained at a level not exceeding as specified in Schedule VI of these regulations;

(g) Any delegation of responsibilities is documented;

(h) No individual incurs a medical exposure as part of a program of biomedical research unless the exposure has been approved by ethics committee (national or provincial level) and dose constraint for biomedical research shall be followed as specified or approved by the ethics committee on case by case basis for the optimization of protection and safety;

(i) Implementation of quality assurance requirements as laid down under these regulations; and

(j) No individual incurs a medical exposure as a carer and comforter unless he has received, and has indicated an understanding of, relevant information on radiation protection and information on the radiation risks prior to providing care and comfort to an individual undergoing a radiological procedure.

43. **Justification of Medical Exposure**.—(1) Medical professionals shall consider the justification of medical exposures that they prescribe by weighing the diagnostic or therapeutic benefits they produce against the radiation detriment they might cause, taking into account the benefits and risks of available alternative techniques that do not involve medical exposure.

(2) The justification of medical exposure for an individual patient particularly, for patients who are pregnant or breast feeding or are pediatric, shall be carried out by taking into account the:

(a) Appropriateness of the request;

(b) Urgency of the radiological procedure;

(c) Characteristics of the medical exposure;

(d) Characteristics of the individual patient; and

(e) Relevant information from the patient's previous radiological procedures.

(3) Relevant national or international referral guidelines shall be taken into account for the justification of the medical exposure of an individual patient in a radiological procedure.

(4) Justification for radiological procedures to be performed as part of health screening program for asymptomatic populations shall be carried out by the health authority.

(5) Any radiological procedure on an asymptomatic individual that is intended to be performed for the early detection of disease, but not as part of an approved health screening program, shall require specific justification for that individual and, the individual shall be informed in advance of the expected benefits, risks and limitations of the radiological procedure.

(6) Mass screening of population groups involving medical exposure is deemed to be not justified unless the expected advantages for the individuals examined or for the population as a whole are sufficient to compensate for the economic and social costs, including the radiation detriment.

44. **Calibration and Clinical Dosimetry for Medical Exposure**.—(1) The licensee shall ensure that:

(a) The calibration of all dosimeters used for dosimetry of patients and the calibration of sources used for medical exposure is traceable to a standard dosimetry laboratory;

(b) Each type of radiotherapy equipment is calibrated in terms of the relevant dosimetric quantities and irradiation conditions;

(c) All sources giving rise to medical exposure are calibrated in terms of appropriate quantities; and

(d) Calibrations of equipment are carried out at the time of commissioning of a source, after any maintenance procedure that may affect the calibration, as well as at regular intervals and records are maintained.

(2) The licensee shall ensure that the representative values of clinical dosimetry parameters are determined and documented.

45. **Diagnostic Reference Level for Medical Exposure**.—(1) Diagnostic reference levels for medical exposure, as specified in Schedule VIII of these regulations, shall be used by medical professionals in the conduct of radiological procedures involving exposure to radiation as well as in the optimization of protection of patients.

(2) The licensee may use other diagnostic reference levels with prior approval from the Authority.

46. **Quality Assurance for Medical Exposure**.—(1) The licensee shall establish a quality assurance program under management system for medical exposure which shall include:

(a) Measurements of the physical parameters of the medical radiological equipment:

(i) At the time of acceptance and commissioning prior to its clinical use on patients;

(ii) Periodically thereafter;

(iii) After any major maintenance procedure that could affect protection and safety of patients; and

(iv) After any installation of new software or modification of existing software that could affect protection and safety of patients.

(b) Implementation of corrective actions if measured values of the physical parameters are outside established tolerance limits;

(c) Verification of the appropriate clinical factors used in patient diagnosis or treatment;

(d) Written records of relevant procedures and results;

(e) Periodic checks of calibration and operational conditions of dosimetry equipment and monitoring equipment; and

(f) As far as possible, regular and independent quality audit reviews of the quality assurance process.

47. **Dose Constraints**.—The licensee shall constrain any dose to individuals incurred while voluntarily helping (other than in their occupation) in the care, support or comfort of patients undergoing radiological procedure, and to visitors of patients who have received therapeutic amounts of radionuclides or who are being treated with brachytherapy sources, to a level not exceeding that specified in Schedule VI of these regulations.

48. **Pregnant or Breast Feeding Patients**.—(1) The licensee shall ensure that instructions in national and local languages are placed in public places, waiting rooms for patients, cubicles and other appropriate places, and that other means of communication are also used as appropriate, to request female patients who are to undergo a radiological procedure to notify the medical professional or technologist or other personnel in the event that:

(a) She is or might be pregnant; and

(b) She is breast feeding and the scheduled radiological procedure includes the administration of a radiopharmaceutical.

(2) The licensee shall ensure that there are procedures in place to determine the pregnancy status of a female patient of reproductive capacity before the performance of any radiological procedure that could result in a

significant dose to the embryo or fetus, so that this information can be considered in the justification for the radiological procedure and in the optimization of protection and safety.

(3) The licensee shall ensure that there are arrangements in place for establishing that a female patient is not currently breast feeding before the performance of any radiological procedure involving the administration of a radiopharmaceutical that could result in a significant dose to a breastfed infant, so that this information can be considered in the justification for the radiological procedure and in the optimization of protection and safety.

49. **Release of Patients after Radionuclide Therapy**.—(1) The licensee shall ensure that no patient who has undergone a therapeutic radiological procedure with a sealed or unsealed radioactive source is discharged from a medical radiation facility before the activity of radioactive substances in the body falls below the level specified in Schedule IX of these regulations unless otherwise justified and the justification is documented.

(2) The licensee shall ensure that patient or the guardian of the patient is provided with:

(a) Written instructions for keeping doses to persons in contact with or in the vicinity of the patient as low as reasonably achievable and for avoiding the spread of contamination; and

(b) Information on the radiation risks.

50. **Investigation of Unintended or Accidental Medical Exposure**.—(1) The licensee, shall ensure that all practicable measures are taken to minimize the likelihood of unintended or accidental medical exposures arising from flaws in design and operational failures of medical radiological equipment, from failures of and errors in software, or as a result of human error.

(2) The licensee shall promptly investigate any:

(a) Medical treatment delivered to the wrong patient or to the wrong tissue or organ of the patient, or using the wrong radiopharmaceutical or with an activity, or a dose or dose fractionation differing substantially from the values prescribed by the medical professional;

(b) Diagnostic radiological procedure or image guided interventional procedure in which the wrong individual or the wrong tissue or organ of the patient is subject to exposure;

(c) Exposure arising from diagnostic or image guided interventional procedure that is substantially greater than was intended;

(d) Inadvertent exposure of the embryo or fetus in the course of performing a radiological procedure; and

(e) Repeated equipment failure, accident, error, mishap or other unusual occurrence with the potential for causing a patient exposure significantly different from that intended.

(3) The licensee shall notify the Authority, by telephone or facsimile as soon as practicable, but not later than twenty four (24) hours after discovery of the any unintended or accidental medical exposure.

(4) The licensee shall, with respect to any investigation required 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 incident;

(c) Implement all the corrective measures that are under their own responsibility; and

(d) Inform the referring medical practitioner and the patient or the patient's authorized representative.

(5) The licensee shall submit to the Authority, within thirty (30) days after discovery of the incident, a written report which states the cause of the incident and includes the information on the doses, corrective measures and any other relevant information.

51. **Protection and Safety in Handling of Deceased Person**.—In the event of death of a patient that contains sealed or unsealed radioactive sources, the licensee shall maintain records of the deceased person. For ensuring protection and safety in the handling of the deceased persons, the dead body shall be released after giving instructions to the custodians and contact information shall be taken from custodian or legal authorized representative of the deceased person.

52. **Review and Records**.—(1) The licensee shall ensure that radiological reviews are performed periodically by the medical professional at the medical radiation facility, in cooperation with the radiation technologists and the medical physicists.

(2) The licensee shall keep and make available the following records for medical exposure:

(a) For diagnostic radiology, information necessary for retrospective assessment of doses, including the number of exposures and the duration of fluoroscopic radiological procedures;

(b) For image guided interventional procedures, information necessary for retrospective assessment of doses, including the duration of fluoroscopic radiological component and the number of images acquired;

(c) For nuclear medicine, the types of radiopharmaceutical administered and their activity;

(d) For external beam radiation therapy or brachytherapy, a description of the planning target volume, the absorbed dose to the centre of the planning target volume, and the maximum and minimum absorbed doses delivered to the planning target volume, or equivalent alternative information on absorbed doses to the planning target volume, and the absorbed doses to relevant tissues or organs as determined by the medical professional; and in addition, for external beam radiation therapy, the dose fractionation and the overall treatment time;

(e) Records of local assessments and reviews made with regard to diagnostic reference levels;

(f) Exposure records for volunteers subject to medical exposure as part of a program of biomedical research; and

(g) Investigations of unintended and accidental medical exposures.

EXISTING EXPOSURE SITUATIONS

53. **Remediation of Areas with Residual Radioactive Material**.—(1) For remediation of areas with residual radioactive material deriving from past activities or from a nuclear or radiological emergency, the responsible person shall ensure that:

(a) A remedial action plan, supported by a safety assessment, is prepared and implemented;

(b) Any additional doses received by members of the public as a result of the remedial actions are justified;

(c) The exposure of workers undertaking remedial actions is controlled in accordance with the relevant requirements on occupational exposure in planned exposure situations;

(d) A mechanism for public information is in place and a monitoring program is established and implemented;

(e) A system for maintaining adequate records relating to the existing exposure situation is in place; and

(f) Mechanism is in place for reporting to the Authority on any abnormal conditions relevant to protection and safety.

(2) The responsible person shall ensure that:

(a) A radiological survey has been performed after completion of remedial actions to demonstrate that the end point conditions are met, as established in the remedial action plan; and

(b) A final remediation report has been prepared and submitted to the Authority.

(3) After the completion of remedial actions, if the Authority decides that no restrictions or controls are required, the area shall be considered to constitute the background conditions for any new facilities and activities or for habitation on the land.

54. **Exposure due to Radionuclides in Commodities**.—(1) Production, manufacturing or otherwise preparation, storage, sale, import, and export of edible goods in which the radionuclide levels are more than the levels prescribed in Schedule X shall be prohibited.

(2) The Authority may require, as and when deemed necessary, from a person importing edible goods to furnish a certificate issued by the relevant authority of the country of origin specifying radionuclide levels present in the edible goods and that these are not more than those specified in Schedule X.

(3) Unless exempted by the Authority, production, manufacturing or otherwise preparation, storage, sale, import, and export of scrap metal, recycled metal products or other commodities having radiation levels above the natural background shall be prohibited.

(4) The person importing scrap metal and recycled metal products shall furnish a certificate issued by the relevant authority of the country of origin specifying the radiation levels in the scrap. An undertaking shall also be

furnished that if any imported consignment is found to have radiation levels higher than the natural background levels, then the same shall be returned back to the country of origin at his own risk and cost.

(5) All such consignments, shipments and containers may be subject to verification by the concerned local authorities. Whereas, any imported consignment, shipment and container having radiation levels higher than the natural background levels shall be returned back to the country of origin at the cost of consignee.

(6) The Authority may impose restrictions on import of edible goods, and any other specific goods or commodities from a specific country, for a specific time, under special circumstances.

55. **Exposure due to Radon in Workplaces**.—(1) The employers shall ensure that activity concentrations of Rn-222 in workplace are as low as reasonably achievable below the reference level i.e. annual average activity concentration of 1000 Bq/m^3 and shall ensure that protection and safety is optimized.

(2) If, despite all reasonable efforts by the employer to reduce activity concentration of radon, the activity concentration of Rn-222 in workplaces remains above the reference level, the relevant requirements for occupational exposure in planned exposure situations shall apply.

56. **Repeal**.—The "Regulations on Radiation Protection - (PAK/904)" notified *vide* S.R.O. 837(I)/2004 dated 5th October 2004 are hereby repealed.

SCHEDULE I

QUALIFICATION CRITERIA AND TRAINING PERIOD FOR RADIATION PROTECTION OFFICER (RPO)

Sr. No.	Type of Facility	Qualification	#Training Period (Months)
1.	Full Fledged Medical Center	Medical Physicist (Radiotherapy or Nuclear Medicine)	06
2.	Radiotherapy	Medical Physicist (Radiotherapy)	06
3.	Nuclear Medicine	Medical Physicist (Nuclear Medicine)	06
4.	Nuclear Cardiology	Medical Physicist (Nuclear Medicine or Cardiology)	03
5.	Radiology (Department having CT Scanner, Angiography, Fluoroscopy Machine & Mammography etc)	Medical Physicist (Radiology) or Radiologist	03
6.	Irradiator (Sterilization or Food processing)	BS or BE or M.Sc.	12
7.	Irradiator (Blood or Agriculture or Research)	*Qualified Worker	06
8.	Industrial Radiography	*Qualified Worker with RT Level-II	12

9.	Nuclear Gauges (Category 1, 2 & 3 Sources)	*Qualified Worker	03
10.	Oil Well Logging	BS or BE or M.Sc.	06
11.	Manufacturer of Consumer Products	*Qualified Worker	06
12.	Service Providers or Importers or Exporters or Traders (involved in installation, testing and maintenance of radiation generators or apparatus having radioactive sources)	*Qualified Worker	06
13.	Cargo or Vehicle Scanner	BS or BE or M.Sc.	06
14.	Manufacturers of Radioactive Sources or Radioisotope Production Facility	*Qualified Worker	06
15.	Manufacturers of Radiation Generators	*Qualified Worker	03
16.	Calibration and Dosimetry Service Providers	BS or BE or M.Sc.	03

* *the RPO shall undergo on the job training program under a designated RPO of the relevant radiation facility.*

* *an individual who, fulfills the criteria in relevant practice/facility as per Schedule II of these regulations.*

SCHEDULE II

QUALIFICATION CRITERIA FOR PROFESSIONALS

Sr. No.	Designation	Qualification and Experience or Training
(1)	**Medical Applications**	
(a)	*Radiologist	(a) F.C.P.S. or F.R.C.R. (Radiology); or (b) Diplomat American Board (Radiology); or (c) D.M.R.D. or M.C.P.S. (Radiology) with three (03) years practical experience in radiology after post graduation.
(b)	*Radiation Oncologist	(a) F.C.P.S or F.R.C.R (Radiotherapy); or (b) Diplomat American Board (Radiotherapy); or (c) D.M.R.T. or M.C.P.S. (Radiotherapy) with three (03) years practical experience in radiotherapy after post graduation.
(c)	*Nuclear Physician	(a) F.C.P.S. (Nuclear Medicine); or (b) Diplomat American Board (Nuclear Medicine); or (c) MS (Nuclear Medicine) from a university recognized by Higher Education Commission (HEC) with three (03) years practical experience in Nuclear Medicine after post graduation.
(d)	*Nuclear Cardiologist	(a) F.C.P.S. or M.R.C.P. (Cardiology) with M.S. (Nuclear Medicine) and one (01) year practical experience in Nuclear Cardiology; or (b) M.C.P.S. (Cardiology) with M.S. (Nuclear Medicine) and three (03) years practical experience in Nuclear Cardiology.
(e)	Medical Physicist (Radiotherapy)	(a) MS Medical Physics from a HEC recognized university with one (01) year practical experience in radiotherapy; or (b) M.Sc. or BS (Physical sciences) from a HEC recognized university with two (02) years practical experience in radiotherapy.
(f)	Medical Physicist (Nuclear Medicine)	(a) MS Medical Physics from a HEC recognized university with six (06) months practical experience in nuclear medicine; or (b) M.Sc. or BS (Physical sciences) from a HEC recognized university with one (01) year practical experience in nuclear medicine.

Sr. No.	Designation	Qualification and Experience or Training
(g)	Medical Physicist (Radiology)	(a) MS Medical Physics from a HEC recognized university with six (06) months practical experience in radiology; or (b) M.Sc. or BS (Physical sciences) from a HEC recognized university with one (01) year practical experience in radiology.
(h)	Radiopharmacist	D-Pharm or B. Pharm from a HEC recognized university with one (01) year practical experience in Radiopharmacy.
(i)	Radiochemist	M.Sc. or BS Chemistry or equivalent from a HEC recognized university with one (01) year practical experience in Radiochemistry.
(j)	Cyclotron Operator	(a) M.Sc. or BS Physics or its equivalent from a HEC recognized university with one (01) year on the job training in relevant field; or (b) Bachelor Degree in Engineering (Electrical or Electronics or Chemical or Mechanical) or its equivalent from a university or institute recognized by the HEC with one (01) year on the job training in relevant field.
(k)	Technologist (Radiology)	Any one of following or its equivalent from educational institutions or universities recognized by relevant authorities in the country: (a) Matric (Science) with class III, II and I radiographer course in relevant specialty from institutes of Armed Forces of Pakistan; (b) Matric (Science) with two (02) years on the job training at radiology center or department; (c) F.Sc. with one (01) year on the job training at radiology center or department; (d) Diploma in Medical Radiography with six (06) months on the job training in relevant field.
(l)	Technologist (Radiotherapy or Nuclear Medicine)	Any one of following or its equivalent from educational institutions or universities recognized by relevant authorities in the country: (a) Matric (Science) with class III, II and I Radiotherapy or Laboratory Technician course in relevant specialty from institutes of Armed Forces of Pakistan; (b) Diploma in Radiotherapy or Nuclear Medicine with two (02) years on the job training in relevant field; (c) F.Sc. with two (02) years on the job training in relevant field; (d) B.Sc. with one (01) year on the job training in relevant field.
(m)	Technologist (Radioimmunoassay - RIA facilities)	F.Sc. or its equivalent from recognized educational board with six (06) months on the job training in relevant field.
(n)	Non-medical Human Imaging	(a) Matric (Science) or its equivalent from recognized educational board with one (01) year on the job training in relevant field; or (b) D.A.E. or F.Sc. or its equivalent from recognized educational board with six (06) months on the job training in relevant field.
(2)	**Industrial Applications**	
(a)	Industrial Radiographer	Following or its equivalent from educational institutions recognized by relevant authorities in the country: (a) D.A.E, F.Sc. from recognized educational boards with one (01) year on the job training in relevant field; and (b) Radiographic Testing (RT) Level-I Certification.
(b)	Worker in Oil Well Logging	D.A.E. or F.Sc. or its equivalent from recognized educational board with one (01) year on the job training in relevant field.
(c)	Worker dealing Nuclear Gauges	D.A.E. or F.Sc. or its equivalent from recognized educational board with six (06) months on the job training.
(d)	Worker in Material Analysis Facilities using XRD or XRF Spectrometers or Gas Chromatography	D.A.E. or F.Sc. or its equivalent from recognized educational board with three (03) months on the job training in relevant field.

Sr. No.	Designation	Qualification and Experience or Training
(3)	**Irradiators**	
(a)	Worker at Irradiator facilities (Food Processing or Sterilization)	D.A.E. or F.Sc. or its equivalent from recognized educational board with one (01) year on the job training in relevant field.
(b)	Worker at Irradiator facilities (Agriculture or Blood or Research)	D.A.E. or F.Sc. or its equivalent from recognized educational board with six (06) months on the job training in relevant field.
(4)	**Scanners**	
(a)	Worker in facilities using Cargo or Vehicle Scanner	D.A.E or F.Sc. or its equivalent from recognized educational board with six (06) months on the job training in relevant field.
(b)	Worker in facilities using Industrial Scanners or Baggage Scanner	Matric (Science) or its equivalent from recognized educational board with six (06) months on the job training in relevant field.
(5)	**Manufacturers, Traders or Service Providers**	
(a)	Worker in Consumer Products Manufacturing facilities	D.A.E. or F.Sc. or its equivalent from recognized educational board with six (06) months on the job training in relevant field.
(b)	Worker in Radioactive Source Manufacturing facilities	M.Sc. or BS or its equivalent from a H.E.C. recognized university with six (06) months on the job training in relevant field.
(c)	Worker in Trading Facilities involved in Import, Export, Sale of Radioactive Sources	D.A.E. or F.Sc. or its equivalent from recognized educational board with three (03) months on the job training in relevant field.
(d)	Worker in Repair or Maintenance or Testing or Calibration and Dosimetry Services providing facilities	D.A.E. or F.Sc. or its equivalent from recognized educational board with six (06) months on the job training in relevant field.
(e)	Worker in Radiation Generator Manufacturing facilities	D.A.E. or F.Sc. or its equivalent from recognized educational board with six (06) months on the job training in relevant field.
(6)	**Research, Education and Training**	
(a)	Worker in Academic Research, Education and Training facilities	D.A.E. or F.Sc. or its equivalent from recognized educational board with six (06) months on the job training in relevant field.

** all to be registered with PM&DC*

SCHEDULE III

CONTENTS OF TRAINING

The training of professionals shall cover at least the following areas:

(1) Fundamentals of radiation;

(2) Radiation detection and measurement;

(3) Radiation hazards;

(4) Principles of radiation protection;

(5) Case histories of radiological incidents and accidents;

(6) Requirements of relevant PNRA regulations; and

(7) Demonstration of applicable programs/plans and procedures.

SCHEDULE IV

EXEMPTION CRITERIA

(1) Practices or sources within practices may be exempted from the requirements of these regulations if the Authority is satisfied that the following exemption criteria are met:

(a) Radioactive material for which either the total activity of an individual radionuclide present on the premises at any one time or the activity concentration as used in the practice does not exceed the exemption level given in Table 1, 2 & 3; or

(b) Under all reasonably foreseeable circumstances the effective dose expected to be incurred by any member of the public due to the practices or sources is of the order of 10 μSv or less in a year; or

(c) To take into account low probability scenarios, a different criterion could be used, namely that the effective dose expected to be incurred by any individual for such low probability scenarios does not exceed 1 mSv in a year.

(2) Radiation generators of a type approved by the Authority, or in the form of an electronic tube, such as a cathode ray tube for the display of visual images, provided that:

(a) They do not in normal operating conditions cause a dose rate exceeding 1 μSv/h at a distance of 0.1 m from any accessible surface of the equipment; or

(b) The operation of any cathode ray tube intended for the display of visual images or other electrical apparatus operating at a potential difference not exceeding 30 kV, provided that it does not cause in normal operating conditions a dose rate exceeding 1 μSv/h at a distance of 0.1 m from any accessible surface of the apparatus.

(3) Exemption may be granted for equipment containing radioactive material that is not otherwise automatically exempted without further consideration from the requirements of these regulations provided that:

(a) The equipment containing radioactive material is of a type approved by the Authority;

(b) The radioactive material is in the form of a sealed radioactive source that effectively prevents any contact with the radioactive material and prevents its leakage; and

(c) In normal operating conditions, the equipment does not cause dose rate exceeding 1μSv/h at a distance of 0.1m from any accessible surface of the equipment.

(4) For exemption of radioactive material containing more than one radionuclide, on the basis of the levels given in Tables 1, 2 and 3, the condition for exemption from the requirements of these regulations is that the sum of the individual radionuclide activities or activity concentrations, as appropriate, is less than the derived exemption 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 1 or 2 or 3; and n is the number of radionuclides.

(5) The values provided in Table 1 and 2 are not intended to be applied to the control of discharges or to the control of residual radioactive material in the environment.

TABLE 1

LEVELS FOR EXEMPTION OF MODERATE AMOUNTS (≤1000 kg) OF MATERIAL

Radionuclide[a]	Activity Concentration (Bq/g)	Activity (Bq)	Radionuclide[a]	Activity Concentration (Bq/g)	Activity (Bq)
H-3	1×10^6	1×10^9	Be-7	1×10^3	1×10^7
Be-10	1×10^4	1×10^6	C-11	1×10^1	1×10^6
C-14	1×10^4	1×10^7	N-13	1×10^2	1×10^9
Ne-19	1×10^2	1×10^9	O-15	1×10^2	1×10^9
F-18	1×10^1	1×10^6	Na-22	1×10^1	1×10^6
Na-24	1×10^1	1×10^5	Mg-28	1×10^1	1×10^5
Al-26	1×10^1	1×10^5	Si-31	1×10^3	1×10^6

Radionuclide[a]	Activity Concentration (Bq/g)	Activity (Bq)	Radionuclide[a]	Activity Concentration (Bq/g)	Activity (Bq)
Si-32	1×10^3	1×10^6	P-32	1×10^3	1×10^5
P-33	1×10^5	1×10^8	S-35	1×10^5	1×10^8
Cl-36	1×10^4	1×10^6	Cl-38	1×10^1	1×10^5
Cl-39	1×10^1	1×10^5	Ar-37	1×10^6	1×10^8
Ar-39	1×10^7	1×10^4	Ar-41	1×10^2	1×10^9
K-40	1×10^2	1×10^6	K-42	1×10^2	1×10^6
K-43	1×10^1	1×10^6	K-44	1×10^1	1×10^5
K-45	1×10^1	1×10^5	Ca-41	1×10^5	1×10^7
Ca-45	1×10^4	1×10^7	Ca-47	1×10^1	1×10^6
Sc-43	1×10^1	1×10^6	Sc-44	1×10^1	1×10^5
Sc-45	1×10^2	1×10^7	Sc-46	1×10^1	1×10^6
Sc-47	1×10^2	1×10^6	Sc-48	1×10^1	1×10^5
Sc-49	1×10^3	1×10^5	Ti-44	1×10^1	1×10^5
Ti-45	1×10^1	1×10^6	V-47	1×10^1	1×10^5
V-48	1×10^1	1×10^5	V-49	1×10^4	1×10^7
Cr-48	1×10^2	1×10^6	Cr-49	1×10^1	1×10^6
Cr-51	1×10^3	1×10^7	Mn-51	1×10^1	1×10^5
Mn-52	1×10^1	1×10^5	Mn-52m	1×10^1	1×10^5
Mn-53	1×10^4	1×10^9	Mn-54	1×10^1	1×10^6
Mn-56	1×10^1	1×10^5	Fe-52	1×10^1	1×10^6
Fe-55	1×10^4	1×10^6	Fe-59	1×10^1	1×10^6
Fe-60	1×10^2	1×10^5	Co-55	1×10^1	1×10^6
Co-56	1×10^1	1×10^5	Co-57	1×10^2	1×10^6
Co-58	1×10^1	1×10^6	Co-58m	1×10^4	1×10^7

Radionuclide[a]	**Activity Concentration (Bq/g)**	**Activity (Bq)**	**Radionuclide[a]**	**Activity Concentration (Bq/g)**	**Activity (Bq)**
Co-60	1×10^1	1×10^5	Co-60m	1×10^3	1×10^6
Co-61	1×10^2	1×10^6	Co-62m	1×10^1	1×10^5
Ni-56	1×10^1	1×10^6	Ni-57	1×10^1	1×10^6
Ni-59	1×10^4	1×10^8	Ni-63	1×10^5	1×10^8
Ni-65	1×10^1	1×10^6	Ni-66	1×10^4	1×10^7
Cu-60	1×10^1	1×10^5	Cu-61	1×10^1	1×10^6
Cu-64	1×10^2	1×10^6	Cu-67	1×10^2	1×10^6
Zn-62	1×10^2	1×10^6	Zn-63	1×10^1	1×10^5
Zn-65	1×10^1	1×10^6	Zn-69	1×10^4	1×10^6
Zn-69m	1×10^2	1×10^6	Zn-71m	1×10^1	1×10^6
Zn-72	1×10^2	1×10^6	Ga-65	1×10^1	1×10^5
Ga-66	1×10^1	1×10^5	Ga-67	1×10^2	1×10^6
Ga-68	1×10^1	1×10^5	Ga-70	1×10^2	1×10^6
Ga-72	1×10^1	1×10^5	Ga-73	1×10^2	1×10^6
Ge-66	1×10^1	1×10^6	Ge-67	1×10^1	1×10^5
Ge-68[b]	1×10^1	1×10^5	Ge-69	1×10^1	1×10^6
Ge-71	1×10^4	1×10^8	Ge-75	1×10^3	1×10^6
Ge-77	1×10^1	1×10^5	Ge-78	1×10^2	1×10^6
As-69	1×10^1	1×10^5	As-70	1×10^1	1×10^5
As-71	1×10^1	1×10^6	As-72	1×10^1	1×10^5
As-73	1×10^3	1×10^7	As-74	1×10^1	1×10^6
As-76	1×10^2	1×10^5	As-77	1×10^3	1×10^6
As-78	1×10^1	1×10^5	Se-70	1×10^1	1×10^6
Se-73	1×10^1	1×10^6	Se-73m	1×10^2	1×10^6

Radionuclide[a]	Activity Concentration (Bq/g)	Activity (Bq)	Radionuclide[a]	Activity Concentration (Bq/g)	Activity (Bq)
Se-75	1×10^{2}	1×10^{6}	Se-79	1×10^{4}	1×10^{7}
Se-81	1×10^{3}	1×10^{6}	Se-81m	1×10^{3}	1×10^{7}
Se-83	1×10^{1}	1×10^{5}	Br-74	1×10^{1}	1×10^{5}
Br-74m	1×10^{1}	1×10^{5}	Br-75	1×10^{1}	1×10^{6}
Br-76	1×10^{1}	1×10^{5}	Br-77	1×10^{2}	1×10^{6}
Br-80	1×10^{2}	1×10^{5}	Br-80m	1×10^{3}	1×10^{7}
Br-82	1×10^{1}	1×10^{6}	Br-83	1×10^{3}	1×10^{6}
Br-84	1×10^{1}	1×10^{5}	Kr-74	1×10^{2}	1×10^{9}
Kr-76	1×10^{2}	1×10^{9}	Kr-77	1×10^{2}	1×10^{9}
Kr-79	1×10^{3}	1×10^{5}	Kr-81	1×10^{4}	1×10^{7}
Kr-81m	1×10^{3}	1×10^{10}	Kr-83m	1×10^{5}	1×10^{12}
Kr-85	1×10^{5}	1×10^{4}	Kr-85m	1×10^{3}	1×10^{10}
Kr-87	1×10^{2}	1×10^{9}	Kr-88	1×10^{2}	1×10^{9}
Rb-79	1×10^{1}	1×10^{5}	Rb-81	1×10^{1}	1×10^{6}
Rb-81m	1×10^{3}	1×10^{7}	Rb-82m	1×10^{1}	1×10^{6}
Rb-83[b]	1×10^{2}	1×10^{6}	Rb-84	1×10^{1}	1×10^{6}
Rb-86	1×10^{2}	1×10^{5}	Rb-87	1×10^{3}	1×10^{7}
Rb-88	1×10^{2}	1×10^{5}	Rb-89	1×10^{2}	1×10^{5}
Sr-80	1×10^{3}	1×10^{7}	Sr-81	1×10^{1}	1×10^{5}
Sr-82[b]	1×10^{1}	1×10^{5}	Sr-83	1×10^{1}	1×10^{6}
Sr-85	1×10^{2}	1×10^{6}	Sr-85m	1×10^{2}	1×10^{7}
Sr-87m	1×10^{2}	1×10^{6}	Sr-89	1×10^{3}	1×10^{6}
Sr-90[b]	1×10^{2}	1×10^{4}	Sr-91	1×10^{1}	1×10^{5}
Sr-92	1×10^{1}	1×10^{6}	Y-86	1×10^{1}	1×10^{5}

Radionuclide[a]	Activity Concentration (Bq/g)	Activity (Bq)	Radionuclide[a]	Activity Concentration (Bq/g)	Activity (Bq)
Y-86m	1×10^2	1×10^7	Y-87[b]	1×10^1	1×10^6
Y-88	1×10^1	1×10^6	Y-90	1×10^3	1×10^5
Y-90m	1×10^1	1×10^6	Y-91	1×10^3	1×10^6
Y-91m	1×10^2	1×10^6	Y-92	1×10^2	1×10^5
Y-93	1×10^2	1×10^5	Y-94	1×10^1	1×10^5
Y-95	1×10^1	1×10^5	Zr-86	1×10^2	1×10^7
Zr-88	1×10^2	1×10^6	Zr-89	1×10^1	1×10^6
Zr-93[b]	1×10^3	1×10^7	Zr-95	1×10^1	1×10^6
Zr-97[b]	1×10^1	1×10^5	Nb-88	1×10^1	1×10^5
Nb-89	1×10^1	1×10^5	Nb-89m	1×10^1	1×10^5
Nb-90	1×10^1	1×10^5	Nb-93m	1×10^4	1×10^7
Nb-94	1×10^1	1×10^6	Nb-95	1×10^1	1×10^6
Nb-95m	1×10^2	1×10^7	Nb-96	1×10^1	1×10^5
Nb-97	1×10^1	1×10^6	Nb-98	1×10^1	1×10^5
Mo-90	1×10^1	1×10^6	Mo-93	1×10^3	1×10^8
Mo-93m	1×10^1	1×10^6	Mo-99	1×10^2	1×10^6
Mo-101	1×10^1	1×10^6	Tc-93	1×10^1	1×10^6
Tc-93m	1×10^1	1×10^6	Tc-94	1×10^1	1×10^6
Tc-94m	1×10^1	1×10^5	Tc-95	1×10^1	1×10^6
Tc-95m	1×10^1	1×10^6	Tc-96	1×10^1	1×10^6
Tc-96m	1×10^3	1×10^7	Tc-97	1×10^3	1×10^8
Tc-97 m	1×10^3	1×10^7	Tc-98	1×10^1	1×10^6
Tc-99	1×10^4	1×10^7	Tc-99m	1×10^2	1×10^7
Tc-101	1×10^2	1×10^6	Tc-104	1×10^1	1×10^5

Radionuclide[a]	Activity Concentration (Bq/g)	Activity (Bq)	Radionuclide[a]	Activity Concentration (Bq/g)	Activity (Bq)
Ru-94	1×10^2	1×10^6	Ru-97	1×10^2	1×10^7
Ru-103	1×10^2	1×10^6	Ru-105	1×10^1	1×10^6
Ru-106[b]	1×10^2	1×10^5	Rh-99	1×10^1	1×10^6
Rh-99m	1×10^1	1×10^6	Rh-100	1×10^1	1×10^6
Rh-101	1×10^2	1×10^7	Rh-101m	1×10^2	1×10^7
Rh-102	1×10^1	1×10^6	Rh-102m	1×10^2	1×10^6
Rh-103m	1×10^4	1×10^8	Rh-105	1×10^2	1×10^7
Rh-106m	1×10^1	1×10^5	Rh-107	1×10^2	1×10^6
Pd-100	1×10^2	1×10^7	Pd-101	1×10^2	1×10^6
Pd-103	1×10^3	1×10^8	Pd-107	1×10^5	1×10^8
Pd-109	1×10^3	1×10^6	Ag-102	1×10^1	1×10^5
Ag-103	1×10^1	1×10^6	Ag-104	1×10^1	1×10^6
Ag-104m	1×10^1	1×10^6	Ag-105	1×10^2	1×10^6
Ag-106	1×10^1	1×10^6	Ag-106m	1×10^1	1×10^6
Ag-108m	1×10^1	1×10^6	Ag-110m	1×10^1	1×10^6
Ag-111	1×10^3	1×10^6	Ag-112	1×10^1	1×10^5
Ag-115	1×10^1	1×10^5	Cd-104	1×10^2	1×10^7
Cd-107	1×10^3	1×10^7	Cd-109	1×10^4	1×10^6
Cd-113	1×10^3	1×10^6	Cd-113m	1×10^3	1×10^6
Cd-115	1×10^2	1×10^6	Cd-115m	1×10^3	1×10^6
Cd-117	1×10^1	1×10^6	Cd-117m	1×10^1	1×10^6
In-109	1×10^1	1×10^6	In-110	1×10^1	1×10^6
In-110m	1×10^1	1×10^5	In-111	1×10^2	1×10^6
In-112	1×10^2	1×10^6	In-113m	1×10^2	1×10^6

Radionuclide[a]	**Activity Concentration (Bq/g)**	**Activity (Bq)**	**Radionuclide[a]**	**Activity Concentration (Bq/g)**	**Activity (Bq)**
In-114	1×10^3	1×10^5	In-114m	1×10^2	1×10^6
In-115	1×10^3	1×10^5	In-115m	1×10^2	1×10^6
In-116m	1×10^1	1×10^5	In-117	1×10^1	1×10^6
In-117m	1×10^2	1×10^6	In-119m	1×10^2	1×10^5
Sn-110	1×10^2	1×10^7	Sn-111	1×10^2	1×10^6
Sn-113	1×10^3	1×10^7	Sn-117m	1×10^2	1×10^6
Sn-119m	1×10^3	1×10^7	Sn-121	1×10^5	1×10^7
Sn-121m[b]	1×10^3	1×10^7	Sn-123	1×10^3	1×10^6
Sn-123m	1×10^2	1×10^6	Sn-125	1×10^2	1×10^5
Sn-126[b]	1×10^1	1×10^5	Sn-127	1×10^1	1×10^6
Sn-128	1×10^1	1×10^6	Sb-115	1×10^1	1×10^6
Sb-116	1×10^1	1×10^6	Sb-116m	1×10^1	1×10^5
Sb-117	1×10^2	1×10^7	Sb-118m	1×10^1	1×10^6
Sb-119	1×10^3	1×10^7	Sb-120	1×10^2	1×10^6
Sb-120m	1×10^1	1×10^6	Sb-122	1×10^2	1×10^4
Sb-124	1×10^1	1×10^6	Sb-124m	1×10^2	1×10^6
Sb-125	1×10^2	1×10^6	Sb-126	1×10^1	1×10^5
Sb-126m	1×10^1	1×10^5	Sb-127	1×10^1	1×10^6
Sb-128	1×10^1	1×10^5	Sb-128m	1×10^1	1×10^5
Sb-129	1×10^1	1×10^6	Sb-130	1×10^1	1×10^5
Sb-131	1×10^1	1×10^6	Te-116	1×10^2	1×10^7
Te-121	1×10^1	1×10^6	Te-121m	1×10^2	1×10^6
Te-123	1×10^3	1×10^6	Te-123m	1×10^2	1×10^7
Te-125m	1×10^3	1×10^7	Te-127	1×10^3	1×10^6

Radionuclide[a]	**Activity Concentration (Bq/g)**	**Activity (Bq)**	**Radionuclide[a]**	**Activity Concentration (Bq/g)**	**Activity (Bq)**
Te-127m	1×10^3	1×10^7	Te-129	1×10^2	1×10^6
Te-129m	1×10^3	1×10^6	Te-131	1×10^2	1×10^5
Te-131m	1×10^1	1×10^6	Te-132	1×10^2	1×10^7
Te-133	1×10^1	1×10^5	Te-133m	1×10^1	1×10^5
Te-134	1×10^1	1×10^6	I-120	1×10^1	1×10^5
I-120m	1×10^1	1×10^5	I-121	1×10^2	1×10^6
I-123	1×10^2	1×10^7	I-124	1×10^1	1×10^6
I-125	1×10^3	1×10^6	I-126	1×10^2	1×10^6
I-128	1×10^2	1×10^5	I-129	1×10^2	1×10^5
I-130	1×10^1	1×10^6	I-131	1×10^2	1×10^6
I-132	1×10^1	1×10^5	I-132m	1×10^2	1×10^6
I-133	1×10^1	1×10^6	I-134	1×10^1	1×10^5
I-135	1×10^1	1×10^6	Xe-120	1×10^2	1×10^9
Xe-121	1×10^2	1×10^9	Xe-122[b]	1×10^2	1×10^9
Xe-123	1×10^2	1×10^9	Xe-125	1×10^3	1×10^9
Xe-127	1×10^3	1×10^5	Xe-129m	1×10^3	1×10^4
Xe-131m	1×10^4	1×10^4	Xe-133m	1×10^3	1×10^4
Xe-133	1×10^3	1×10^4	Xe-135	1×10^3	1×10^{10}
Xe-135m	1×10^2	1×10^9	Xe-138	1×10^2	1×10^9
Cs-125	1×10^1	1×10^4	Cs-127	1×10^2	1×10^5
Cs-129	1×10^2	1×10^5	Cs-130	1×10^2	1×10^6
Cs-131	1×10^3	1×10^6	Cs-132	1×10^1	1×10^5
Cs-134m	1×10^3	1×10^5	Cs-134	1×10^1	1×10^4
Cs-135	1×10^4	1×10^7	Cs-135m	1×10^1	1×10^6

Radionuclide[a]	**Activity Concentration (Bq/g)**	**Activity (Bq)**	**Radionuclide[a]**	**Activity Concentration (Bq/g)**	**Activity (Bq)**
Cs-136	1×10^{1}	1×10^{5}	Cs-137[b]	1×10^{1}	1×10^{4}
Cs-138	1×10^{1}	1×10^{4}	Ba-126	1×10^{2}	1×10^{7}
Ba-128	1×10^{2}	1×10^{7}	Ba-131	1×10^{2}	1×10^{6}
Ba-131m	1×10^{2}	1×10^{7}	Ba-133	1×10^{2}	1×10^{6}
Ba-133m	1×10^{2}	1×10^{6}	Ba-135m	1×10^{2}	1×10^{6}
Ba-137m	1×10^{1}	1×10^{6}	Ba-139	1×10^{2}	1×10^{5}
Ba-140[b]	1×10^{1}	1×10^{5}	Ba-141	1×10^{2}	1×10^{5}
Ba-142	1×10^{2}	1×10^{6}	La-131	1×10^{1}	1×10^{6}
La-132	1×10^{1}	1×10^{6}	La-135	1×10^{3}	1×10^{7}
La-137	1×10^{3}	1×10^{7}	La-138	1×10^{1}	1×10^{6}
La-140	1×10^{1}	1×10^{5}	La-141	1×10^{2}	1×10^{5}
La-142	1×10^{1}	1×10^{5}	La-143	1×10^{2}	1×10^{5}
Ce-134	1×10^{3}	1×10^{7}	Ce-135	1×10^{1}	1×10^{6}
Ce-137	1×10^{3}	1×10^{7}	Ce-137m	1×10^{3}	1×10^{6}
Ce-139	1×10^{2}	1×10^{6}	Ce-141	1×10^{2}	1×10^{7}
Ce-143	1×10^{2}	1×10^{6}	Ce-144[b]	1×10^{2}	1×10^{5}
Pr-136	1×10^{1}	1×10^{5}	Pr-137	1×10^{2}	1×10^{6}
Pr-138m	1×10^{1}	1×10^{6}	Pr-139	1×10^{2}	1×10^{7}
Pr-142	1×10^{2}	1×10^{5}	Pr-142m	1×10^{7}	1×10^{9}
Pr-143	1×10^{4}	1×10^{6}	Pr-144	1×10^{2}	1×10^{5}
Pr-145	1×10^{3}	1×10^{5}	Pr-147	1×10^{1}	1×10^{5}
Nd-136	1×10^{2}	1×10^{6}	Nd-138	1×10^{3}	1×10^{7}
Nd-139	1×10^{2}	1×10^{6}	Nd-139m	1×10^{1}	1×10^{6}
Nd-141	1×10^{2}	1×10^{7}	Nd-147	1×10^{2}	1×10^{6}

Radionuclide[a]	**Activity Concentration (Bq/g)**	**Activity (Bq)**	**Radionuclide[a]**	**Activity Concentration (Bq/g)**	**Activity (Bq)**
Nd-149	1×10^{2}	1×10^{6}	Nd-151	1×10^{1}	1×10^{5}
Pm-141	1×10^{1}	1×10^{5}	Pm-143	1×10^{2}	1×10^{6}
Pm-144	1×10^{1}	1×10^{6}	Pm-145	1×10^{3}	1×10^{7}
Pm-146	1×10^{1}	1×10^{6}	Pm-147	1×10^{4}	1×10^{7}
Pm-148	1×10^{1}	1×10^{5}	Pm-148m	1×10^{1}	1×10^{6}
Pm-149	1×10^{3}	1×10^{6}	Pm-150	1×10^{1}	1×10^{5}
Pm-151	1×10^{2}	1×10^{6}	Sm-141	1×10^{1}	1×10^{5}
Sm-141m	1×10^{1}	1×10^{6}	Sm-142	1×10^{2}	1×10^{7}
Sm-145	1×10^{2}	1×10^{7}	Sm-146	1×10^{1}	1×10^{5}
Sm-147	1×10^{1}	1×10^{4}	Sm-151	1×10^{4}	1×10^{8}
Sm-153	1×10^{2}	1×10^{6}	Sm-155	1×10^{2}	1×10^{6}
Sm-156	1×10^{2}	1×10^{6}	Eu-145	1×10^{1}	1×10^{6}
Eu-146	1×10^{1}	1×10^{6}	Eu-147	1×10^{2}	1×10^{6}
Eu-148	1×10^{1}	1×10^{6}	Eu-149	1×10^{2}	1×10^{7}
Eu-150	1×10^{1}	1×10^{6}	Eu-150m	1×10^{3}	1×10^{6}
Eu-152	1×10^{1}	1×10^{6}	Eu-152m	1×10^{2}	1×10^{6}
Eu-154	1×10^{1}	1×10^{6}	Eu-155	1×10^{2}	1×10^{7}
Eu-156	1×10^{1}	1×10^{6}	Eu-157	1×10^{2}	1×10^{6}
Eu-158	1×10^{1}	1×10^{5}	Gd-145	1×10^{1}	1×10^{5}
Gd-146[b]	1×10^{1}	1×10^{6}	Gd-147	1×10^{1}	1×10^{6}
Gd-148	1×10^{1}	1×10^{4}	Gd-149	1×10^{2}	1×10^{6}
Gd-151	1×10^{2}	1×10^{7}	Gd-152	1×10^{1}	1×10^{4}
Gd-153	1×10^{2}	1×10^{7}	Gd-159	1×10^{3}	1×10^{6}
Tb-147	1×10^{1}	1×10^{6}	Tb-149	1×10^{1}	1×10^{6}

Radionuclide[a]	Activity Concentration (Bq/g)	Activity (Bq)	Radionuclide[a]	Activity Concentration (Bq/g)	Activity (Bq)
Tb-150	1×10^{1}	1×10^{6}	Tb-151	1×10^{1}	1×10^{6}
Tb-153	1×10^{2}	1×10^{7}	Tb-154	1×10^{1}	1×10^{6}
Tb-155	1×10^{2}	1×10^{7}	Tb-156	1×10^{1}	1×10^{6}
Tb-156m (24.4 h)	1×10^{3}	1×10^{7}	Tb-156m′ (5 h)	1×10^{4}	1×10^{7}
Tb-157	1×10^{4}	1×10^{7}	Tb-158	1×10^{1}	1×10^{6}
Tb-160	1×10^{1}	1×10^{6}	Tb-161	1×10^{3}	1×10^{6}
Dy-155	1×10^{1}	1×10^{6}	Dy-157	1×10^{2}	1×10^{6}
Dy-159	1×10^{3}	1×10^{7}	Dy-165	1×10^{3}	1×10^{6}
Dy-166	1×10^{3}	1×10^{6}	Ho-155	1×10^{2}	1×10^{6}
Ho-157	1×10^{2}	1×10^{6}	Ho-159	1×10^{2}	1×10^{6}
Ho-161	1×10^{2}	1×10^{7}	Ho-162	1×10^{2}	1×10^{7}
Ho-162m	1×10^{1}	1×10^{6}	Ho-164	1×10^{3}	1×10^{6}
Ho-164m	1×10^{3}	1×10^{7}	Ho-166	1×10^{3}	1×10^{5}
Ho-166m	1×10^{1}	1×10^{6}	Ho-167	1×10^{2}	1×10^{6}
Er-161	1×10^{1}	1×10^{6}	Er-165	1×10^{3}	1×10^{7}
Er-169	1×10^{4}	1×10^{7}	Er-171	1×10^{2}	1×10^{6}
Er-172	1×10^{2}	1×10^{6}	Tm-162	1×10^{1}	1×10^{6}
Tm-166	1×10^{1}	1×10^{6}	Tm-167	1×10^{2}	1×10^{6}
Tm-170	1×10^{3}	1×10^{6}	Tm-171	1×10^{4}	1×10^{8}
Tm-172	1×10^{2}	1×10^{6}	Tm-173	1×10^{2}	1×10^{6}
Tm-175	1×10^{1}	1×10^{6}	Yb-162	1×10^{2}	1×10^{7}
Yb-166	1×10^{2}	1×10^{7}	Yb-167	1×10^{2}	1×10^{6}
Yb-169	1×10^{2}	1×10^{7}	Yb-175	1×10^{3}	1×10^{7}
Yb-177	1×10^{2}	1×10^{6}	Yb-178	1×10^{3}	1×10^{6}

Radionuclide[a]	Activity Concentration (Bq/g)	Activity (Bq)	Radionuclide[a]	Activity Concentration (Bq/g)	Activity (Bq)
Lu-169	1×10^{1}	1×10^{6}	Lu-170	1×10^{1}	1×10^{6}
Lu-171	1×10^{1}	1×10^{6}	Lu-172	1×10^{1}	1×10^{6}
Lu-173	1×10^{2}	1×10^{7}	Lu-174	1×10^{2}	1×10^{7}
Lu-174m	1×10^{2}	1×10^{7}	Lu-176	1×10^{2}	1×10^{6}
Lu-176m	1×10^{3}	1×10^{6}	Lu-177	1×10^{3}	1×10^{7}
Lu-177m	1×10^{1}	1×10^{6}	Lu-178	1×10^{2}	1×10^{5}
Lu-178m	1×10^{1}	1×10^{5}	Lu-179	1×10^{3}	1×10^{6}
Hf-170	1×10^{2}	1×10^{6}	Hf-172[b]	1×10^{1}	1×10^{6}
Hf-173	1×10^{2}	1×10^{6}	Hf-175	1×10^{2}	1×10^{6}
Hf-177m	1×10^{1}	1×10^{5}	Hf-178m	1×10^{1}	1×10^{6}
Hf-179m	1×10^{1}	1×10^{6}	Hf-180m	1×10^{1}	1×10^{6}
Hf-181	1×10^{1}	1×10^{6}	Hf-182	1×10^{2}	1×10^{6}
Hf-182m	1×10^{1}	1×10^{6}	Hf-183	1×10^{1}	1×10^{6}
Hf-184	1×10^{2}	1×10^{6}	Ta-172	1×10^{1}	1×10^{6}
Ta-173	1×10^{1}	1×10^{6}	Ta-174	1×10^{1}	1×10^{6}
Ta-175	1×10^{1}	1×10^{6}	Ta-176	1×10^{1}	1×10^{6}
Ta-177	1×10^{2}	1×10^{7}	Ta-178	1×10^{1}	1×10^{6}
Ta-179	1×10^{3}	1×10^{7}	Ta-180	1×10^{1}	1×10^{6}
Ta-180m	1×10^{3}	1×10^{7}	Ta-182	1×10^{1}	1×10^{4}
Ta-182m	1×10^{2}	1×10^{6}	Ta-183	1×10^{2}	1×10^{6}
Ta-184	1×10^{1}	1×10^{6}	Ta-185	1×10^{2}	1×10^{5}
Ta-186	1×10^{1}	1×10^{5}	W-176	1×10^{2}	1×10^{6}
W-177	1×10^{1}	1×10^{6}	W-178[b]	1×10^{1}	1×10^{6}
W-179	1×10^{2}	1×10^{7}	W-181	1×10^{3}	1×10^{7}

Radionuclide[a]	**Activity Concentration (Bq/g)**	**Activity (Bq)**	**Radionuclide[a]**	**Activity Concentration (Bq/g)**	**Activity (Bq)**
W-185	1×10^4	1×10^7	W-187	1×10^2	1×10^6
W-188[b]	1×10^2	1×10^5	Re-177	1×10^1	1×10^6
Re-178	1×10^1	1×10^6	Re-181	1×10^1	1×10^6
Re-182	1×10^1	1×10^6	Re-182m	1×10^1	1×10^6
Re-184	1 × 101	1×10^6	Re-184m	1×10^2	1×10^6
Re-186	1×10^3	1×10^6	Re-186m	1×10^3	1×10^7
Re-187	1×10^6	1×10^9	Re-188	1×10^2	1×10^5
Re-188m	1×10^2	1×10^7	Re-189[b]	1×10^2	1×10^6
Os-180	1×10^2	1×10^7	Os-181	1×10^1	1×10^6
Os-182	1×10^2	1×10^6	Os-185	1×10^1	1×10^6
Os-189m	1×10^4	1×10^7	Os-191	1×10^2	1×10^7
Os-191m	1×10^3	1×10^7	Os-193	1×10^2	1×10^6
Os-194[b]	1×10^2	1×10^5	Ir-182	1×10^1	1×10^5
Ir-184	1×10^1	1×10^6	Ir-185	1×10^1	1×10^6
Ir-186	1×10^1	1×10^6	Ir-186m	1×10^1	1×10^6
Ir-187	1×10^2	1×10^6	Ir-188	1×10^1	1×10^6
Ir-189[b]	1×10^2	1×10^7	Ir-190	1×10^1	1×10^6
Ir-190m (3.1 h)	1×10^1	1×10^6	Ir-190m′ (1.2 h)	1×10^4	1×10^7
Ir-192	1×10^1	1×10^4	Ir-192m	1×10^2	1×10^7
Ir-193m	1×10^4	1×10^7	Ir-194	1×10^2	1×10^5
Ir-194m	1×10^1	1×10^6	Ir-195	1×10^2	1×10^6
Ir-195m	1×10^2	1×10^6	Pt-186	1×10^1	1×10^6
Pt-188[b]	1×10^1	1×10^6	Pt-189	1×10^2	1×10^6
Pt-191	1×10^2	1×10^6	Pt-193	1×10^4	1×10^7

Radionuclide[a]	**Activity Concentration (Bq/g)**	**Activity (Bq)**	**Radionuclide[a]**	**Activity Concentration (Bq/g)**	**Activity (Bq)**
Pt-193m	1×10^3	1×10^7	Pt-195m	1×10^2	1×10^6
Pt-197	1×10^3	1×10^6	Pt-197m	1×10^2	1×10^6
Pt-199	1×10^2	1×10^6	Pt-200	1×10^2	1×10^6
Au-193	1×10^2	1×10^7	Au-194	1×10^1	1×10^6
Au-195	1×10^2	1×10^7	Au-198	1×10^2	1×10^6
Au-198m	1×10^1	1×10^6	Au-199	1×10^2	1×10^6
Au-200	1×10^2	1×10^5	Au-200m	1×10^1	1×10^6
Au-201	1×10^2	1×10^6	Hg-193	1×10^2	1×10^6
Hg-193m	1×10^1	1×10^6	Hg-194[b]	1×10^1	1×10^6
Hg-195	1×10^2	1×10^6	Hg-195m[b]	1×10^2	1×10^6
Hg-197	1×10^2	1×10^7	Hg-197m	1×10^2	1×10^6
Hg-199m	1×10^2	1×10^6	Hg-203	1×10^2	1×10^5
Tl-194	1×10^1	1×10^6	Tl-194m	1×10^1	1×10^6
Tl-195	1×10^1	1×10^6	Tl-197	1×10^2	1×10^6
Tl-198	1×10^1	1×10^6	Tl-198m	1×10^1	1×10^6
Tl-199	1×10^2	1×10^6	Tl-200	1×10^1	1×10^6
Tl-201	1×10^2	1×10^6	Tl-202	1×10^2	1×10^6
Tl-204	1×10^4	1×10^4	Pb-195m	1×10^1	1×10^6
Pb-198	1×10^2	1×10^6	Pb-199	1×10^1	1×10^6
Pb-200	1×10^2	1×10^6	Pb-201	1×10^1	1×10^6
Pb-202	1×10^3	1×10^6	Pb-202m	1×10^1	1×10^6
Pb-203	1×10^2	1×10^6	Pb-205	1×10^4	1×10^7
Pb-209	1×10^5	1×10^6	Pb-210[b]	1×10^1	1×10^4
Pb-211	1×10^2	1×10^6	Pb-212[b]	1×10^1	1×10^5

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

Radionuclide[a]	**Activity Concentration (Bq/g)**	**Activity (Bq)**	**Radionuclide[a]**	**Activity Concentration (Bq/g)**	**Activity (Bq)**
Pa-231	1×10^{0}	1×10^{3}	Pa-232	1×10^{1}	1×10^{6}
Pa-233	1×10^{2}	1×10^{7}	Pa-234	1×10^{1}	1×10^{6}
U-230[b]	1×10^{1}	1×10^{5}	U-231	1×10^{2}	1×10^{7}
U-232[b]	1×10^{0}	1×10^{3}	U-233	1×10^{1}	1×10^{4}
U-234	1×10^{1}	1×10^{4}	U-235[b]	1×10^{1}	1×10^{4}
U-236	1×10^{1}	1×10^{4}	U-237	1×10^{2}	1×10^{6}
U-238[b]	1×10^{1}	1×10^{4}	U-239	1×10^{2}	1×10^{6}
U-240	1×10^{3}	1×10^{7}	U-240[b]	1×10^{1}	1×10^{6}
Np-232	1×10^{1}	1×10^{6}	Np-233	1×10^{2}	1×10^{7}
Np-234	1×10^{1}	1×10^{6}	Np-235	1×10^{3}	1×10^{7}
Np-236	1×10^{2}	1×10^{5}	Np-236m	1×10^{3}	1×10^{7}
Np-237[b]	1×10^{0}	1×10^{3}	Np-238	1×10^{2}	1×10^{6}
Np-239	1×10^{2}	1×10^{7}	Np-240	1×10^{1}	1×10^{6}
Pu-234	1×10^{2}	1×10^{7}	Pu-235	1×10^{2}	1×10^{7}
Pu-236	1×10^{1}	1×10^{4}	Pu-237	1×10^{3}	1×10^{7}
Pu-238	1×10^{0}	1×10^{4}	Pu-239	1×10^{0}	1×10^{4}
Pu-240	1×10^{0}	1×10^{3}	Pu-241	1×10^{2}	1×10^{5}
Pu-242	1×10^{0}	1×10^{4}	Pu-243	1×10^{3}	1×10^{7}
Pu-244	1×10^{0}	1×10^{4}	Pu-245	1×10^{2}	1×10^{6}
Pu-246	1×10^{2}	1×10^{6}	Am-237	1×10^{2}	1×10^{6}
Am-238	1×10^{1}	1×10^{6}	Am-239	1×10^{2}	1×10^{6}
Am-240	1×10^{1}	1×10^{6}	Am-241	1×10^{0}	1×10^{4}
Am-242	1×10^{3}	1×10^{6}	Am-242m[b]	1×10^{0}	1×10^{4}
Am-243[b]	1×10^{0}	1×10^{3}	Am-244	1×10^{1}	1×10^{6}

Radionuclide[a]	**Activity Concentration (Bq/g)**	**Activity (Bq)**	**Radionuclide[a]**	**Activity Concentration (Bq/g)**	**Activity (Bq)**
Am-244m	1×10^4	1×10^7	Am-245	1×10^3	1×10^6
Am-246	1×10^1	1×10^5	Am-246m	1×10^1	1×10^6
Cm-238	1×10^2	1×10^7	Cm-240	1×10^2	1×10^5
Cm-241	1×10^2	1×10^6	Cm-242	1×10^2	1×10^5
Cm-243	1×10^0	1×10^4	Cm-244	1×10^1	1×10^4
Cm-245	1×10^0	1×10^3	Cm-246	1×10^0	1×10^3
Cm-247	1×10^0	1×10^4	Cm-248	1×10^0	1×10^3
Cm-249	1×10^3	1×10^6	Cm-250	1×10^{-1}	1×10^3
Bk-245	1×10^2	1×10^6	Bk-246	1×10^1	1×10^6
Bk-247	1×10^0	1×10^4	Bk-249	1×10^3	1×10^6
Bk-250	1×10^1	1×10^6	Cf-244	1×10^4	1×10^7
Cf-246	1×10^3	1×10^6	Cf-248	1×10^1	1×10^4
Cf-249	1×10^0	1×10^3	Cf-250	1×10^1	1×10^4
Cf-251	1×10^0	1×10^3	Cf-252	1×10^1	1×10^4
Cf-253	1×10^2	1×10^5	Cf-254	1×10^0	1×10^3
Es-250	1×10^2	1×10^6	Es-251	1×10^2	1×10^7
Es-253	1×10^2	1×10^5	Es-254	1×10^1	1×10^4
Es-254m	1×10^2	1×10^6	Fm-252	1×10^3	1×10^6
Fm-253	1×10^2	1×10^6	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	Md-258	1×10^2	1×10^5

[a] *m and m' denote metastable states of the radionuclide. The metastable state m' is of higher energy than the metastable state m.*

[b] *Parent radionuclides and their progeny whose dose contributions are taken into account in the dose calculations (thus requiring only the exemption level of the parent radionuclide to be considered) are listed here:*

Ge-68	Ga-68	Sr-82	Rb-82
Rb-83	Kr-83m	Y-87	Sr-87m
Sr-90	Y-90	Zr-93	Nb-93m
Zr-97	N b-97	Ru-106	Rh-106
Ag-108m	Ag-108	Sn-121m	Sn-121 (0.776)
Xe-122	I-122	Sn-126	Sb-126m
Ce-134	La-134	Cs-137	Ba-137m
Ba-140	La-140	Ce-144	Pr-144
Gd-146	Eu-146	Hf-172	Lu-172
W-178	Ta-178	W-188	Re-188
Re-189	Os-189m (0.241)	Ir-189	Os-189m
Pt-188	Ir-188	Hg-194	Au-194
Hg-195m	Hg-195 (0.542)	Pb-210	Bi-210, Po-210
Bi-210m	Tl-206	Pb-212	Bi-212, Tl-208 (0.36), Po-212 (0.64)
Bi-212	Tl-208 (0.36), Po-212 (0.64)	Rn-220	Po-216
Rn-222	Po-218, Pb-214, Bi-214, Po-214	Ra-223	Rn-219, Po-215, Pb-211, Bi-211, Tl-207
Ra-224	Rn-220, Po-216, Pb-212, Bi-212, Tl-208 (0.36), Po-212 (0.64)	Ac-225	Fr-221, At-217, Bi-213, Po-213 (0.978), Tl-209 (0.0216), Pb-209 (0.978)
Ra-226	Rn-222, Po-218, Pb-214, Bi-214, Po-214, Pb-210, Bi-210, Po-210	Th-226	Ra-222, Rn-218, Po-214
Ac-227	Fr-223 (0.0138)	Ra-228	Ac-228
Th-228	Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Tl-208 (0.36), Po-212 (0.64)	Th-229	Ra-225, Ac-225, Fr-221, At-217, Bi-213, Po-213, Pb-209
U-230	Th-226, Ra-222, Rn-218, Po-214	U-232	Th-228, Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Tl-208 (0.36), Po-212 (0.64)
Th-234	Pa-234m	U-235	Th-231
Np-237	Pa-233	U-238	Th-234, Pa-234m
U-240	Np-240m	Am-242m	Am-242
Am-243	Np-239	-	-

TABLE 2

LEVELS FOR EXEMPTION OF BULK AMOUNTS (> 1000 kg) OF SOLID MATERIAL (ACTIVITY CONCENTRATIONS OF *RADIONUCLIDES OF ARTIFICIAL ORIGIN)

Radionuclide	Activity Concentration (Bq/g)	Radionuclide	Activity Concentration (Bq/g)
H-3	100	Be-7	10

Radionuclide	Activity Concentration (Bq/g)	Radionuclide	Activity Concentration (Bq/g)
C-14	1	F-18	10
Na-22	0.1	Na-24	1
Si-31	1000	P-32	1000
P-33	1000	S-35	100
Cl-36	1	Cl-38	10
K-42	100	K-43	10
Ca-45	100	Ca-47	10
Sc-46	0.1	Sc-47	100
Sc-48	1	V-48	1
Cr-51	100	Mn-51	10
Mn-52	1	Mn-52m	10
Mn-53	100	Mn-54	0.1
Mn-56	10	Fe-52[a]	10
Fe-55	1 000	Fe-59	1
Co-55	10	Co-56	0.1
Co-57	1	Co-58	1
Co-58m	10000	Co-60	0.1
Co-60m	1000	Co-61	100
Co-62m	10	Ni-59	100
Ni-63	100	Ni-65	10
Cu-64	100	Zn-65	0.1
Zn-69	1000	Zn-69m[a]	10
Ga-72	10	Ge-71	10000
As-73	1000	As-74	10

Radionuclide	Activity Concentration (Bq/g)	Radionuclide	Activity Concentration (Bq/g)
As-76	10	As-77	1000
Se-75	1	Br-82	1
Rb-86	100	Sr-85	1
Sr-85m	100	Sr-87m	100
Sr-89	1000	Sr-90[a]	1
Sr-91[a]	10	Sr-92	10
Y-90	1000	Y-91	100
Y-91m	100	Y-92	100
Y-93	100	Zr-93	10
Zr-95[a]	1	Zr-97[a]	10
Nb-93m	10	Nb-94	0.1
Nb-95	1	Nb-97[a]	10
Nb-98	10	Mo-90	10
Mo-93	10	Mo-99[a]	10
Mo-101[a]	10	Tc-96	1
Tc-96m	1000	Tc-97	10
Tc-97m	100	Tc-99	1
Tc-99m	100	Ru-97	10
Ru-103[a]	1	Ru-105[a]	10
Ru-106[a]	0.1	Rh-103m	10000
Rh-105	100	Pd-103[a]	1000
Pd-109[a]	100	Ag-105	1
Ag-110m[a]	0.1	Ag-111	100
Cd-109[a]	1	Cd-115[a]	10

Radionuclide	Activity Concentration (Bq/g)	Radionuclide	Activity Concentration (Bq/g)
Cd-115m[a]	100	In-111	10
In-113m	100	In-114m[a]	10
In-115m	100	Sn-113[a]	1
Sn-125	10	Sb-122	10
Sb-124	1	Sb-125[a]	0.1
Te-123m	1	Te-125m	1000
Te-127	1000	Te-127m[a]	10
Te-129	100	Te-129m[a]	10
Te-131	100	Te-131m[a]	10
Te-132[a]	1	Te-133	10
Te-133m	10	Te-134	10
I-123	100	I-125	100
I-126	10	I-129	0.01
I-130	10	I-131	10
I-132	10	I-133	10
I-134	10	I-135	10
Cs-129	10	Cs-131	1000
Cs-132	10	Cs-134	0.1
Cs-134m	1000	Cs-135	100
Cs-136	1	Cs-137[a]	0.1
Cs-138	10	Ba-131	10
Ba-140	1	La-140	1
Ce-139	1	Ce-141	100
Ce-143	10	Ce-144[a]	10

Radionuclide	Activity Concentration (Bq/g)	Radionuclide	Activity Concentration (Bq/g)
Pr-142	100	Pr-143	1000
Nd-147	100	Nd-149	100
Pm-147	1000	Pm-149	1000
Sm-151	1000	Sm-153	100
Eu-152	0.1	Eu-152m	100
Eu-154	0.1	Eu-155	1
Gd-153	10	Gd-159	100
Tb-160	1	Dy-165	1000
Dy-166	100	Ho-166	100
Er-169	1000	Er-171	100
Tm-170	100	Tm-171	1000
Yb-175	100	Lu-177	100
Hf-181	1	Ta-182	0.1
W-181	10	W-185	1000
W-187	10	Re-186	1000
Re-188	100	Os-185	1
Os-191	100	Os-191m	1000
Os-193	100	Ir-190	1
Ir-192	1	Ir-194	100
Pt-191	10	Pt-193m	1000
Pt-197	1000	Pt-197m	100
Au-198	10	Au-199	100
Hg-197	100	Hg-197m	100
Hg-203	10	Tl-200	10

Radionuclide	Activity Concentration (Bq/g)	Radionuclide	Activity Concentration (Bq/g)
Tl-201	100	Tl-202	10
Tl-204	1	Pb-203	10
Bi-206	1	Bi-207	0.1
Po-203	10	Po-205	10
Po-207	10	At-211	1000
Ra-225	10	Ra-227	100
Th-226	1000	Th-229	0.1
Pa-230	10	Pa-233	10
U-230	10	U-231	100
U-232[a]	0.1	U-233	1
U-236	10	U-237	100
U-239	100	U-240[a]	100
Np-237[a]	1	Np-239	100
Np-240	10	Pu-234	100
Pu-235	100	Pu-236	1
Pu-237	100	Pu-238	0.1
Pu-239	0.1	Pu-240	0.1
Pu-241	10	Pu-242	0.1
Pu-243	1000	Pu-244[a]	0.1
Am-241	0.1	Am-242	1000
Am-242m[a]	0.1	Am-243[a]	0.1
Cm-242	10	Cm-243	1
Cm-244	1	Cm-245	0.1
Cm-246	0.1	Cm-247[a]	0.1

Radionuclide	Activity Concentration (Bq/g)	Radionuclide	Activity Concentration (Bq/g)
Cm-248	0.1	Bk-249	100
Cf-246	1000	Cf-248	1
Cf-249	0.1	Cf-250	1
Cf-251	0.1	Cf-252	1
Cf-253	100	Cf-254	1
Es-253	100	Es-254[a]	0.1
Es-254m[a]	10	Fm-254	10000
Fm-255	100	-	-

[a] *Parent radionuclides, and their progeny whose dose contributions are taken into account in the dose calculations (thus requiring only the exemption level of the parent radionuclide to be considered), are listed here:*

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	Te-132	I-132
Nb-97	Nb-97m	Cs-137	Ba-137m
Mo-99	Tc-99m	Ce-144	Pr-144, Pr-144m
Mo-101	Tc-101	U-232	Th-228, Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Tl-208
Ru-103	Rh-103m	U-240	Np-240m, Np-240
Ru-105	Rh-105m	Np-237	Pa-233
Ru-106	Rh-106	Pu-244	U-240, Np-240m, Np-240
Pd-103	Rh-103m	Am-242m	Np-238
Pd-109	Ag-109m	Am-243	Np-239
Ag-110m	Ag-110	Cm-247	Pu-243
Cd-109	Ag-109m	Es-254	Bk-250
Cd-115	In-115m	Es-254m	Fm-254
Cd-115m	In-115m		
In-114m	In-114		

** those radionuclides for which there is no corresponding value given in Table 2, the values given in Table 1 may be applied*

TABLE 3

LEVELS FOR EXEMPTION OF MATERIAL (ACTIVITY CONCENTRATIONS OF RADIONUCLIDE OF NATURAL ORIGIN)

Radionuclide	Activity Concentration (Bq/g)
K-40	10
Each radionuclide in the uranium decay chain or the thorium decay chain	1

SCHEDULE V

CATEGORIES FOR SEALED SOURCES

Table 1 shows categories for sealed sources used in common practices, and Table 2 shows the activity corresponding to a dangerous source (D value) for selected radionuclides.

TABLE 1

CATEGORIES FOR SEALED SOURCES USED IN COMMON PRACTICES

Category	Ratio of activity in the Source to Activity that is Considered Dangerous* (*A*/D)	Example of Sources and Practices
1	$A/D \geq 1000$	Radioisotope thermoelectric generators; Irradiators; Teletherapy sources; Fixed multibeam teletherapy (‘gamma knife’) sources.
2	$1000 > A/D \geq 10$	Industrial gamma radiography sources; High/medium dose rate brachytherapy sources.
3	$10 > A/D \geq 1$	Fixed industrial gauges incorporating high activity sources; Well logging gauges.
4	$1 > A/D \geq 0.01$	Low dose rate brachytherapy sources (except eye plaques and permanent implants); Industrial gauges not incorporating high activity sources; Bone densitometers; Static eliminators.
5	$0.01 > A/D$ and A > level for exemption	Low dose rate brachytherapy eye plaques and permanent implant sources; X-ray fluorescence devices;- Electron capture devices; Mossbauer spectrometry sources; Positron emission tomography check sources.

** A is the activity of the radionuclide in a source and D is the activity of that radionuclide that is regarded as dangerous. A dangerous source is defined as one that could, if not under control, give rise to exposure sufficient to cause severe deterministic effects.*

TABLE 2

ACTIVITY CORRESPONDING TO A DANGEROUS SOURCE (D VALUE) FOR SELECTED RADIONUCLIDES

Radionuclide	D Value (TBq)	Radionuclide	D Value (TBq)
Am-241	6×10^{-2}	Mo-99	3×10^{-1}
Am-241/Be	6×10^{-2}	Ni-63	6×10^{1}
Au-198	2×10^{-1}	P-32	1×10^{1}
Cd-109	2×10^{1}	Pd-103	9×10^{1}
Cf-252	2×10^{-2}	Pm-147	4×10^{1}
Cm-244	5×10^{-2}	Po-210	6×10^{-2}
Co-57	7×10^{-1}	Pu-238	6×10^{-2}
Co-60	3×10^{-2}	Pu-239/Be	6×10^{-2}
Cs-137	1×10^{-1}	Ra-226	4×10^{-2}
Fe-55	8×10^{2}	Ru-106 (Rh-106)	3×10^{-1}
Gd-153	1×10^{0}	Se-75	2×10^{-1}
Ge-68	7×10^{-2}	Sr-90 (Y-90)	1×10^{0}
H-3	2×10^{3}	Tc-99m	7×10^{-1}
I-125	2×10^{-1}	Tl-204	2×10^{1}
I-131	2×10^{-1}	Tm-170	2×10^{1}
Ir-192	8×10^{-2}	Yb-169	3×10^{-1}
Kr-85	3×10^{1}	-	-

SCHEDULE VI

DOSE LIMITS

TABLE 1

ANNUAL DOSE LIMITS FOR RADIATION WORKERS (Aged 18 Years and Above)

Organ or Tissue	Dose Quantity	Dose Limits (mSv)
Whole body	effective dose	20*
Lens of the eye	equivalent dose	20**
Extremities (hands and feet) or Skin (average dose over 1 cm^2 of the most highly irradiated area).	equivalent dose	500

* *An effective dose of up to 50 mSv in any single year provided that the average dose over five consecutive years does not exceed 20 mSv/year.*

** *An equivalent dose of up to 50 mSv in any single year provided that the average dose over five consecutive years does not exceed 20 mSv/year.*

*TABLE 2

ANNUAL DOSE LIMITS FOR APPRENTICES/STUDENTS (16 to 18 Years of Age)

Organ or Tissue	Dose Quantity	Dose Limits (mSv)
Whole body	effective dose	6
Lens of the eye	equivalent dose	20
Extremities (hands and feet) or Skin (average dose over 1 cm^2 of the most highly irradiated area).	equivalent dose	150

** For occupational exposure of apprentices of sixteen (16) to eighteen (18) years of age who are being trained for employment involving radiation and for exposure of students of age Sixteen (16) to eighteen (18) who use sources in the course of their studies.*

TABLE 3

ANNUAL DOSE LIMITS FOR PUBLIC

Organ or Tissue	Dose Quantity	Dose Limits (mSv)
Whole body	effective dose	1*
Lens of the eye	equivalent dose	15
Extremities (hands and feet) or Skin (average dose over 1 cm^2 of the most highly irradiated area).	equivalent dose	50

** In special circumstances, a higher value of effective dose in a single year could apply, provided that the average effective dose over five (05) consecutive years does not exceed 1 mSv per year.*

TABLE 4

DOSE LIMITS FOR COMFORTERS OR VISITORS OF PATIENTS

Organ or Tissue	Dose Quantity	Dose Limits (mSv)
Whole body(Adult)	effective dose	5
Whole body (Children)	effective dose	< 1

SCHEDULE VII

HEALTH SURVEILLANCE

(1) General tests:

(a) Blood CP (Haemoglobin, ESR, TLC, DLC, RBC & WBC with Morphology);

(b) Urine (Routine) examination; and

(c) Chest X-Ray, if needed.

(2) In case of suspected abnormal exposure or as recommended by medical practitioner, in addition to above following tests shall be required:

Blood Tests	**Urine examination**
(a) Clotting Profile	(a) Routine Examination
(b) Platelet Counts	(b) Renal Function Tests
(c) HLA Typing	
(d) Serum Electrolytes (Sodium, Potassium etc.)	
(e) Serum Proteins	
(f) Serum Urea/Creatinine	

(3) If the nature of work is such that the possibility of exposure through ingestion or inhalation can be expected to occur, in addition to blood and urine examinations, following tests are required as deemed appropriate:

(a) Fecal Examination (Routine & bioassay for radionuclides);

(b) Bioassay of Urine for Radionuclides;

(c) Examinations of other body fluids like Sweat, Saliva, etc. for radionuclide detection;

(d) Thyroid Function Tests;

(e) Thyroid Scan; and

(f) Whole Body Scanning.

(4) Psychiatric examination as deemed necessary by the Authority.

(5) In addition to above, if any test results indicate some kind of abnormality, the following tests are required to be conducted:

(a) Bone Scanning;

(b) Serum Electrophoresis;

(c) Blood Cytogenic Analysis and Radionuclide Detection Tests on Blood or Urine; and

(d) Any other special test as desired by the treating medical practitioner.

SCHEDULE VIII

DIAGNOSTIC REFERENCE LEVELS FOR MEDICAL EXPOSURE[#]

TABLE 1

DIAGNOSTIC REFERENCE LEVELS FOR DIAGNOSTIC RADIOGRAPHY FOR A TYPICAL ADULT PATIENT

Examination	Entrance Surface Dose per Radiograph[a] (mGy)	
Lumbar spine	AP LAT LSJ	10 30 40
Abdomen, intravenous urography and cholecystography	AP	10
Pelvis Hip joint Chest	AP AP PA	10 10 0.4
Thoracic spine	LAT AP	1.5 7
Dental	LAT Periapical AP	20 7 5
Skull	PA LAT	5 3

Notes: PA: posterior- anterior projection; LAT: lateral projection; LSJ: lumbo -sacral - joint projection; AP: anterior- posterior projection.

[a] In air with backscatter. These values are for conventional film -screen combination in the relative speed of 200. For high speed film -screen combinations (400 - 600), the values should be reduced by a factor of 2 to 3.

TABLE 2

DIAGNOSTIC REFERENCE LEVELS FOR COMPUTED TOMOGRAPHY FOR A TYPICAL ADULT PATIENT

Examination	Multiple Scan Average Dose[a] (mGy)
Head	50
Lumbar Spine	35
Abdomen	25

[a] Derived from measurements on the axis of rotation in water equivalent phantoms, 15 cm in length and 16 cm (head) and 30 cm (lumbar spine and abdomen) in diameter.

TABLE 3

DIAGNOSTIC REFERENCE LEVELS FOR MAMMOGRAPHY FOR A TYPICAL ADULT PATIENT

Average glandular dose per cranio-caudal projection[a]
1 mGy (without grid)
3 mGy (with grid)

[a] *Determined in a 4.5 cm compressed breast consisting of 50% glandular and 50% adipose tissue, for film-screen systems and dedicated Mo-target Mo-filter mammography units.*

TABLE 4

DIAGNOSTIC REFERENCE LEVELS FOR FLUOROSCOPY FOR A TYPICAL ADULT PATIENT

Mode of Operation	Entrance Surface Dose Rate[a] (mGy/min)
Normal	25
High level[b]	100

[a] *In air with backscatter.*

[b] *For fluoroscopes that have an optional 'high level' operational mode, such as those frequently used in interventional radiology.*

TABLE 5

DIAGNOSTIC REFERENCE LEVELS FOR PROCEDURES IN NUCLEAR MEDICINE FOR A TYPICAL ADULT PATIENT

Test	Radionuclide	Chemical Form[a]	Maximum Usual Activity per Test[b] (MBq)
Bone			
Bone imaging	Tc-99m	Phosphonate and Phosphate compounds	600
Bone imaging by single photon emission computerized tomography (SPECT)	Tc-99m	Phosphonate and Phosphate compounds	800
Bone marrow imaging	Tc-99m	Labelled colloid	400
Brain			
Brain imaging (static)	Tc-99m Tc-99m	TcO^-_4 Diethylenetriaminepentaacetic acid (DTPA), gluconate and glucoheptonate	500 500
Brain imaging (SPECT)	Tc-99m Tc-99m	TcO^-_4 DTPA, gluconate and Glucoheptonate	800 800
Cerebral blood flow	Tc-99m Xe-133 Tc-99m	Exametazime In isotonic sodium chloride solution Hexamethyl propylene amine oxime (HM-PAO)	500 400 500
Cisternography	In-111	DTPA	40

Lacrimal			
Lacrimal drainage	Tc-99m Tc-99m	TcO^{1}_{4} Labelled colloid	4 4
Thyroid			
Thyroid imaging	Tc-99m I-123	TcO^{-}_{4} I^{-}	200 20
Thyroid metastases (after ablation)	I-131	I^{-}	400
Parathyroid imaging	Tl-201 Tc-99m	Tl^{+}, chloride Tetrofosmin, MIBI	80 900
Lung			
Lung ventilation imaging	Kr-81m Tc-99m	Gas DTPA –aerosol	6000 80
Lung ventilation study	Xe-133 Xe-123	Gas Gas	400 200
Lung perfusion imaging	Kr-81m Tc-99m	Aqueous solution Human albumin (macroaggregates or microspheres)	6000 100
Lung perfusion imaging (with venography)	Tc-99m	Human albumin (macroaggregates or microspheres)	160
Lung perfusion studies	Xe-133 Xe-127	Isotonic solution Isotonic chloride solution	200 200
Lung imaging (SPECT)	Tc-99	Macroaggregated albumin (MAA)	200
Liver and spleen			
Liver and spleen imaging	Tc-99m	Labelled colloid	80
Functional biliary system Imaging	Tc-99m	Iminodiacetates and equivalent agents	150
Spleen imaging	Tc-99m	Labelled denaturated red blood cells	100
Liver imaging (SPECT)	Tc-99m	Labelled colloid	200
Cardiovascular			
First pass blood flow Studies	Tc-99m Tc-99m Tc-99m	TcO^{-}_{4} DTPA Macroaggregated globulin 3	800 800 400
Blood pool imaging	Tc-99m	Human albumin complex	40
Cardiac and vascular imaging/probe studies	Tc-99m Tc-99m	Human albumin complex Labelled normal red blood Cells	800 800
Myocardial imaging/probe studies	Tc-99m	Phosphonate and Phosphate compounds	600
Myocardial imaging	Tc-99m Tl-201	Isonitriles Tl+ Chloride	300 100
Myocardial imaging (SPECT)	Tc-99m Tc-99m	Phosphonate and Phosphate compounds Isonitriles	800 600
Stomach, gastrointestinal tract			
Stomach/salivary gland imaging	Tc-99m	TcO^{-}_{4}	40
Meckel's diverticulum Imaging	Tc-99m	TcO^{-}_{4}	400
Gastrointestinal bleeding	Tc-99m Tc-99m	Labelled colloid Labelled normal red blood Cells	400 400

Oesophageal transit and reflux Gastric emptying	Tc-99m Tc-99m Tc-99m In-111 In-113	Labelled colloid Non–absorbable compounds Non–absorbable compounds Non–absorbable compounds Non–absorbable compounds	40 40 12 12 12
Kidney, urinary system and adrenals			
Renal imaging	Tc-99m	Dimercaptosuccinic acid	160
Renal imaging/renography	Tc-99m Tc-99m I-123	DTPA, glirconate and Glucoheptonate Macroaggregated globulin 3 O-iodohippurate	350 100 20
Adernal imaging	Se-75	Selenorcholesterol	8
Miscellaneous			
Tumour or abscess Imaging	Ga-67 Tl-201	Citrate Chloride	300 100
Tumour imaging	Tc-99m	Dimercaptosuccinic acid	400
Neuroectodermal tumour imaging	I-123 I-131	Meta-iodo-benzyl guanidine Meta-iodo-benzyl guanidine	400 20
Lymph node imaging	Tc-99m	Labelled colloid	80
Abscess imaging	Tc-99m	Exametazime labelled white Cells	400
Thrombus imaging	In-111 In-111	Labelled white cells Labelled platelets	20 20

[a] *In some countries some of the compounds are considered obsolete.*

[b] *In some countries the typical values are lower than those indicated in the table.*

[#] *For pediatric exposure, diagnostic reference levels published in national or international guidelines may be used.*

SCHEDULE IX

ACTIVITY LEVELS FOR RELEASE OF PATIENTS AFTER RADIONUCLIDE THERAPY

Radionuclide	**Activity (MBq)**	**Radionuclide**	**Activity (MBq)**
Ag-111	19000	Re-186	28000
Au-198	3500	Re-188	29000
Cr-51	4800	Sc-47	11000
Cu-64	8400	Se-75	89
Cu-67	14000	Sm-153	26000
Ga-67	8700	Sn-117m	1100
I-123	6000	Tc-99m	28000
I-125	250	Tl-201	16000
I-131	800	Yb-169	370
In-111	2400	-	-

SCHEDULE X

RADIONUCLIDES LEVEL

TABLE 1

RADIATION LEVELS FOR RADIONUCLIDES IN DRINKING WATER

Radionuclide*	Level (Bq/L)
H-3	10000
**C-14	100
Sr-90, **I-131, Cs-134, Cs-137, ***U-238	10
Ra-226, Th-228, Th-230, Th-232, U-234, Pu-239, Am-241	1
Pb-210, Po-210, Ra-228	0.1

* *K-40, a radionuclide that occurs naturally in a fixed ratio to stable potassium, is not included. This is because potassium is an essential element for humans and its concentration in the body is controlled by metabolic processes. If the screening level of 1 Bq/L for gross beta activity concentration is exceeded, a separate determination of total potassium is made and the contribution of K-40 to beta activity is subtracted.*

** *H-3 and I-131 will not be detected by standard gross alpha or gross beta activity measurements. Separate analyses are necessary only if there is reason to believe that these radionuclides may be present.*

*** *Uranium is normally controlled on the basis of its chemical toxicity.*

TABLE 2

RADIATION LEVELS FOR RADIONUCLIDE IN FOOD ITEMS

Radionuclide	Target Organ	Limits of Activity Concentration (Bq/Kg)
Sr-90	Bone surface (infant)	20
Cs-134	Whole body (adult)	50
Cs-137	Whole body (adult)	100
Pu-239	Bone surface (infant)	2

Exception:

Milk powder shall be treated as being diluted seven (7) times with water when made ready for use, therefore, the limits of concentration as given above shall be multiplied by a factor of seven (7).

TABLE 3

RADIATION LEVELS FOR RADIONUCLIDES IN FOODS WITH CONTAMINATION FOLLOWING A NUCLEAR OR RADIOLOGICAL EMERGENCY

Product name	Representative Radionuclide	Guideline Level (Bq/kg)
Infant foods*	Pu-238, Pu-239, Pu-240, Am-241	1
	Sr-90, Ru-106, l-129, I-131, U-235	100
	**S-35, Co-60, Sr-89, Ru-103, Cs-134, Cs-137, Ce-144, Ir-192	1000
	***H-3, C-14, Tc-99	1000
Foods other than infant foods	Pu-238, Pu-139, Pu-240, Am-241	10
	Sr-90, Ru-106, l-129, l-131, U-235	100
	**S-35, Co-60, Sr-89, Ru-103, Cs-134, Cs-137, Ce-144, Ir-192	1000
	***H-3, C-14, Tc-99	10000

** When intended for use as such.*

*** Represents the value for organically bound sulphur.*

**** Represents the value for organically bound tritium.*

Formula for addition:

This Schedule shall be applicable to any of the above single radionuclide present in the food. When two or more radionuclides are found to be present, the formula applicable in such cases shall be worked according to the following sums:

$$S = \frac{\text{Actual level of radionuclide A}}{\text{Limit for radionuclide A}} + \frac{\text{Actual level of radionuclide B}}{\text{Limit for radionuclide B}} \ldots \text{etc.} \leq 1$$

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