Regulatory Guide

Radiation Safety

(FANR-RG-007)

Version 1

Federal Authority for Nuclear Regulation (FANR)

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Basic Principle of Regulatory Guides

The Federal Authority for Nuclear Regulation (i.e. the Authority) issues regulatory guides to describe methods and/ or criteria acceptable to the Authority for meeting and implementing specific and legally enforceable requirements set out in the Authority's regulations. Regulatory guides are not regulations, and compliance with them is not required. Achieving compliance with regulatory requirements in a manner different to that offered by regulatory guides can be acceptable if the alternative approaches provide assurance that requirements are met.

Definitions

Article (1)

Capitalised terms used but not defined herein shall have the meaning ascribed to them in Article 1 of the Federal Law by Decree No. (6) of 2009 Concerning the Peaceful Uses of Nuclear Energy (the Law) and in FANR Regulation on Basic Safety Standards for Facilities and Activities involving Ionizing Radiation other than in Nuclear Facilities (FANR-REG-24) as amended. For the purpose of this regulatory guide, the following terms shall have the meanings set forth below.

Activity Concentration	The radioactivity per unit mass of a material in which the radionuclides are essentially uniformly distributed.
ALARA	As Low As Reasonably Achievable
Representative Person	An individual receiving a Dose that is representative of the more highly exposed individuals in the population.
Controlled Area	A defined area in which specific protective measures or Safety provisions are or could be required for a) controlling normal exposures; b) preventing the spread of contamination during normal working conditions; or c) preventing or limiting the extent of potential exposures.
Defence-in-Depth	A hierarchical deployment of different levels of diverse equipment and procedures to prevent the escalation of anticipated operational occurrences and 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.

Diagnostic Reference Level

A level used in medical imaging to indicate whether, in routine conditions, the Dose to the patient or the quantity of Radioactive Material administered in a specified radiological procedure is unusually high or low.

Diagnostic Reference Levels are established following consultation with health competent authorities and relevant professional bodies, and are based on surveys or published values appropriate to the circumstances in the State.

Dose Constraint

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

Effective Dose

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

$$E = \sum_T w_T . H_T$$

From the definition of Equivalent Dose, it follows that where w_R is the Radiation Weighting Factor for radiation R and $D_{T,R}$ is the average absorbed Dose in the organ or tissue

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

External Events

Events unconnected with the Operation of a Facility or the conduct of a Covered Activity, which could have an effect on the Safety of the Facility or Covered Activity.

Incident(s)	Any unintended event, including operating errors, equipment failures, initiating events, Accident precursors, near-misses or other mishaps, or an unauthorised act malicious or non-malicious; the consequences or potential consequences of which are not negligible from the point of view of protection or Safety.
Justification	The process of determining whether the conduct or a set of related conducts of a Regulated Activity using Regulated Material is overall beneficial, i.e. whether the benefits to individuals and to the society from introducing or continuing the conduct or conducts outweigh the resulting harm (including radiation detriment).
Medical Exposure	Exposure incurred by patients for the purpose of medical or dental diagnosis or treatment; by carers and comforters; and by volunteers in a programme of biomedical research involving their exposure.
Operational States	States defined under normal operation and anticipated operational occurrences
Optimisation	The process of determining what level of Protection and Safety makes exposures, and the probability and magnitude of potential exposures "as low as reasonably achievable" with economic and social factors being taken into account" (ALARA), as required by the International Commission on Radiological Protection System of Radiological Protection. Optimise, Optimised and Optimising shall be construed accordingly.
Protection and Safety	The protection of people against exposure to Ionising Radiation or Radioactive Material and the Safety of Radiation Sources, including the means for achieving this, and the means for preventing Accidents, and for mitigating the consequences of Accidents should they occur.
Qualified Expert	An individual, who by virtue of certification by appropriate boards or societies, professional licences or academic qualifications and experience is duly recognised as having expertise in a relevant field of specialisation.

Radiation Protection Officer (RPO)	A technically competent Person in Radiation Protection for a given type of Regulated Activity with Regulated Material who is designated by the Licensee to oversee the application of relevant requirements established in FANR-REG-24.
Safety Culture	The assembly of characteristics and attitudes in organisations and individuals, which establishes that as an overriding priority, Protection and Safety issues receive the attention warranted by their significance.
Supervised Area	A defined area not already designated as a Controlled Area but where Occupational Exposure conditions need to be kept under review even though specific protective measures and Safety provisions are not normally needed.
Worker(s)	Any Person who works full-time, part-time or on a temporary basis for a Licensee and who has recognised rights and duties in relation to occupational Radiation Protection.

Purpose and Structure

Article (2)

This is a regulatory guide to help the Authority's Licensees who possess, use, manufacture, handle, store, transport or dispose of Regulated Material to understand and comply with the Authority's Regulation for Basic Safety Standards for Facilities and Activities involving Ionizing Radiation other than in Nuclear Facilities (FANR-REG-24). Full details of the references used in this regulatory guide can be found in Article 36. Each reference will be numbered in brackets and abbreviated, for example: [Ref. 1].

Exemptions and Licensing

Article (3)

1. In Article 2 and Schedule I of FANR-REG-24, as amended, the Authority sets amounts of radioactivity and Activity Concentrations below which the Authority does not regulate. A Person as defined in the Law who is responsible for Covered Activities and facilities using amounts of radioactivity and Activity Concentrations above he amounts stipulated in Article 2 and Schedule I of FANR-REG-24, as amended, must have a Licence unless granted an Exemption under Article 5 of FANR-REG-24, as amended, or Articles 5 and 6 of FANR Regulation on the Licensing of Regulated Activities in Facilities other than Nuclear Facilities (FANR-REG-29). Several specific situations are discussed below:

a) Multiple exempt sources:

i. A Person may have several small sources each of which is below the limits the Authority will regulate, but for which the total radioactivity exceeds the value in Table I-(1) of Schedule I of FANR-REG-24, as amended. Such a Person may need to have a Licence from the Authority.

ii. The Person may need a Licence even if small sources are stored in separate locations. The relevant articles of FANR-REG-24, as amended, apply whenever there is sufficient Radioactive Material to have a potential impact on Safety. For example, the Person will need to establish and ensure that appropriate arrangements are made to manage inventory at the end of its useful life. The Authority will consider the need for a Licence on a case-by-case basis in line with Article 5 of FANR-REG-24, as amended.

b) Exemption of sources no longer subject to regulation :

i. A Person who has a Radioactive Source or sources believed collectively to fall below regulatory limits should contact the Authority to seek an Exemption under Article 5 of FANR-REG-24, as amended.

ii. It should be noted that there are additional regulatory requirements for materials containing plutonium, uranium or thorium. These materials, defined by FANR-REG-10 as 'Nuclear Material', are subject to the Safeguards Agreement and the additional requirements should be considered when seeking Exemption in accordance with FANR-REG-24 or FANR-REG-29. FANR-REG-10 should be consulted to determine the requirements for Nuclear Material, including "Exemption from Safeguards" and "consumption and dilution".

c) Exemptions:

i. In accordance with the provisions in Article 5 of FANR-REG-24, as amended, a Person may apply for Exemption if the Regulated Activity can be shown to meet the relevant criteria set out in that article.

ii. The Authority is developing a regulatory framework to further detail the inventory that is subject to Exemption and the evidence to be provided to the Authority when seeking exemption.

d) Seeking, amending and surrendering a Licence:

i. A Person in possession or potentially in possession of Radioactive Material or other Regulated Material must immediately notify the Authority of the material.

Based on the safeguards, radiation or security risks associated with the radioactivity or specified Regulated Material, the Authority will implement full or limited Regulatory Control. Based on this decision, the Authority may issue a Licence authorising the use of the material with or without imposing conditions on the Operation of the Facility.

ii. A Licence holder authorised to perform Regulated Activity using Regulated Material must obtain an amendment to the Licence before modifying a Regulated Activity or a practice involving Regulated Material. This includes any amendments to the inventory such as the introduction of new types/ modalities of inventory items for the same regulated purpose. An amendment to the Licence is also required when changes to the Controlled Areas of a Facility or pertaining to Protection and Safety arrangements are made for whatever reason. The following cases are examples of situations subject to Licence amendment:

    a) Establishment of a new or modified Controlled Area or cancellation of an established Controlled Area, unless the Controlled Area is approved as temporary.

    b) Increased Dose Constraints for the public or Workers.

    c) Increase or decrease of the number of inventory items or increase of inventory item parameters such as output (kV, mAs) or activity (Bq) etc.

    d) Site Construction restricting electricity or water supply in a manner that affects the dilution of radioactive effluents from the Facility either temporarily or permanently, or the irregular Operation of the Facility due to power shortages.

    e) Change in occupancy factors or exposure level for the public or Workers due to reassignment of areas in the Facility or its neighbouring area. For example, areas once occupied by Facility's staff now being made available to the public.

iii. According to business needs, the Licensee may surrender the Licence in full or stop performing part of the Regulated Activities within the scope of the Licence. Ceasing Regulated Activities involving Regulated Material must be done by amending the Licence as described above. The Licence may be terminated in full only when it can be demonstrated that the Licensee is no longer in possession of any Regulated Material, and has satisfied all Licence conditions. It is important to note that the Licensee cannot surrender an expired Licence. The surrender of a Licence is solely subject to the Authority's decision; the

Licensee cannot surrender a licence without authorisation regardless of the Licensee's business.

Clearance

Article (4)

1. When regulated Radioactive Material decays below the limits set out in Schedule I of FANR-REG-24, as amended, and can be demonstrated to comply with criteria in Article 6 of FANR-REG-24, as amended, the Licensee may seek the Authority's approval to release regulatory control over the material.

2. Materials that arise from activities involving Radioactive Material most commonly subject to Clearance are usually liquid or gaseous effluents, or contaminated items such as overalls, gloves, syringes, cotton swaps, catheters or similar.

3. Radioactive Material in the form of a sealed Radioactive Source, which is unsuitable for further use, is not fit for disposal in municipal waste. A Licensee in possession of a sealed Radioactive Source without foreseen use is required to return the source to its manufacturer. In cases where the source cannot be returned, the Licensee must ensure that the source is stored in a condition compliant with arrangements for Pre-disposal for sealed sources as stipulated in FANR Regulatory Guide on the Pre-disposal Management of Radioactive Waste (FANR-RG-018). The Licensee may also be authorised to transfer the source to an approved recycling company in another country if such service is unavailable in the United Arab Emirates. In either case, the manufacturer's source documentation provides the basis for approval of the chosen end-of-life management option for the source. For this reason, the Licensee is required to keep documentation on the inventory throughout the source's life cycle.

4. Regulated Material must remain under Regulatory Control until the Authority approves a status change to custody transfer for the Radioactive Material. The Licensee must continuously maintain its inventory and update the Authority on changes to all records on cleared Radioactive Material. The Authority should be provided with a written statement on Clearance for cleared inventory items.

Justification

Article (5)

1. In accordance with Article 7 of FANR-REG-24, as amended, a Person seeking to undertake a Regulated Activity must establish that the practice involving a Regulated

Material meets the principle of Justification. The Justification principle requires that the benefits of the practice outweigh the risks associated with it. Before implementing and continuing to conduct the practice, the Person must demonstrate that the benefit to individuals and to society outweighs the harm, including the radiation detriment.

2. The Authority accepts that the practices listed below meet the principle of Justification if performed in accordance with internationally-accepted standards. However, if any of these practices (in particular security-screening, research and education) involves radiation exposure to humans (even indirectly) for reasons other than medical diagnosis or treatment, the Authority requires that the practices be justified on a case-by-case basis:

    a) Diagnostic radiology: medical, dental and veterinary,

    b) Nuclear medicine, including a positron emission topography computed topography (PET-CT) scan,

    c) Immunoassay,

    d) Radiotherapy,

    e) Industrial radiography,

    f) Measuring using a gauge,

    g) Well-logging,

    h) Irradiation,

    i) Security-screening,

    j) Training,

    k) Research and education.

3. With regard to the imaging of humans for non-medical purposes, Article 7 of FANR-REG-24, as amended, applies, and a Justification is required.

4. The Authority expects that any novel application of radiation other than the listed above be subject to an explicit process of Justification along the lines of that required for human imaging for purposes other than medical purposes.

5. In the case of Medical Exposure in addition to the generic Justification for diagnostic radiology, nuclear medicine and radiotherapy, Article 33 of FANR-REG-24, as amended, requires that radiological procedures be generically justified by the competent health authority in conjunction with the appropriate professional bodies. The Authority regards this requirement as being met if the procedure is part of normal medical practice consistent

with guidelines issued by national and international professional bodies, and the practice is undertaken by a practitioner licensed by the relevant health authority.

Optimisation of Protection and Safety

Article (6)

1. Optimisation is the process of determining the probability and magnitude of potential exposures and ensuring that they are as low as reasonably achievable (otherwise known as 'ALARA') with economic and social factors being taken into account. In accordance with the ALARA principle, the Licensee must establish and implement Protection and Safety measures that achieve an acceptable outcome for the practice with the lowest achievable exposure. Article 12 of FANR-REG-24, as amended, describes the elements of a management programme for Optimisation of Protection and Safety.

2. Articles 8 and 20 of FANR-REG-24, as amended, require that the Licensee ensures an Optimised level of Protection and Safety for Workers. Articles 9 and 29 of FANR-REG-24, as amended, require that the Licensee ensures an Optimised level of Protection and Safety for the public. Articles 32 and 34 of FANR-REG-24, as amended, require that the Licensee ensures that Medical Exposures are Optimised.

3. The Licensee's Optimisation process for every Facility and Covered Activity must include Dose Constraints. Protection and Safety measures must ensure that the Dose Constraint values are not exceeded. Guidance on Dose Constraint values by practice can be found in Article 7 of this regulatory guide.

Dose Constraints

Article (7)

1. An important tool in achieving the Optimisation of Protection and Safety is the setting of Dose Constraints. A Dose Constraint is a fraction of the Dose limits set out in Articles 9 and 10 of FANR-REG-24, as amended. If the Dose limits are exceeded, the Operator will assess the cause to ensure the practice continues to be optimised, and to identify opportunities to improve the Operation of the Facility.

2. As per Article 17 of FANR-REG-24, as amended, if a Dose Constraint is exceeded the Licensee should initiate an investigation to identify the reasons in order to ensure that remedial measures may be taken to prevent a recurrence. The investigation may show that appropriate levels of Protection and Safety are in place, but the Dose Constraint needs

to be adjusted. Investigations should also be initiated if an investigation level (see Article 8) is exceeded. The Authority finds the following Dose Constraints generally acceptable:

a) Occupational Dose Constraints

i. Occupational Dose Constraints are established by the Licensee and should be practice-specific. The table below contains occupational Dose Constraints the Authority finds reasonable for Workers who are required by the nature of their work to be in areas where exposure takes place.

Table (1): **Occupational Dose Constraints the Authority finds reasonable**

Practice	Occupational Dose Constraint mSv/ year
Industrial radiography, irradiators and accelerators, nuclear medicine, radiotherapy	6
Diagnostic radiology, fixed gauges, portable gauges, X-ray scanners, well-logging	3

ii. The Authority finds 1 mSv/ year to be a reasonable occupational Dose Constraint for Workers undertaking Regulated Activities within shielded dedicated booths or consoles, or outside engineered enclosures where Radiation Sources are used.

b) Public Dose Constraints

i. A Dose Constraint for Public Exposure to radiation or for releases of Radioactive Material must not exceed the Authority's public Dose limits. Further, the Dose Constraint should be sufficiently low to ensure the annual sum of Doses from all exposures whenever and wherever the exposures remain within the Dose limit for the average member of the critical group. For example, a Dose Constraint applied to a Licensee's release of Radioactive Waste to sewers should be low enough that no member of the public, particularly sewage treatment workers, can receive a Dose greater than the limits set by the Authority. In this case, the Dose Constraint should also take into account the possibility that other Licensees may also be releasing contaminated waste into the same sewer system.

ii. Article 9 of FANR-REG-24, as amended, states that the public Dose Constraint is subject to the agreement of the Authority. After considering recommendations of the International Atomic Energy Agency (IAEA) [Ref. 1], the Authority has established the guidance below on public Dose Constraints for Licensees:

Table (2): **Public Dose Constraints for Licensees**

Public Dose Constraint mSv/ year	Authority's Position
Up to 0.1	Acceptable without further basis
0.1 to 0.3	Acceptable if the Licensee provides a reason to explain why a Dose Constraint of 0.1 mSv/ year is impractical
Greater than 0.3	Unacceptable

c) Medical Dose Constraints

i) The Authority endorses the International Commission on Radiological Protection (ICRP) Publication 94 [Ref. 2], which recommends that infants and young children, and visitors not engaged in direct care be treated as members of the public for radiological protection purposes (i.e. subject to the public Dose limit of 1 mSv/ year). Such Persons should be subject to a Dose Constraint that is usually a fraction of that limit. An example of such a Dose Constraint would be 0.3 mSv or less for each procedure performed on a patient.

ii) For individuals directly involved in care other than infants and children under the age of 10 years [Ref. 3], a Dose Constraint of 5 mSv per session (i.e. for the duration of a given release after each session of nuclear medicine) is reasonable. The constraint should be used flexibly; for example, higher Doses may well be appropriate for parents of very sick children.

iii) The Authority has not established Dose Constraints for Persons who receive Medical Exposures as part of a biomedical research programme, as such Dose Constraints should be specific to the programme; they should be proposed by healthcare or research professionals and approved by an ethics committee or similar institutional body.

Investigation Levels

Article (8)

1. Investigation levels are tools to help achieve Protection and Safety. Article 22 of FANR-REG-24, as amended, requires that the Licensee establish written rules and procedures for the Protection and Safety of Workers and other people. Such rules approved by the Authority should include the values of any relevant investigation level and the procedure to be followed in the event that any such value is exceeded.

2. An investigation level is the Effective Dose, Dose rate, intake, or contamination per unit area or volume that is established by the Licensee at or above which an investigation should be conducted. When investigation levels are exceeded, the Licensee should initiate a review of the protection arrangements to address the cause and learn from the event with a view to continuous improvement of operations at the Facility. Exceeding an investigation level is not necessarily prior evidence of a compromised Protection and Safety arrangement as there may be technically grounded reasons for this circumstance.

3. Investigation levels for an individual Dose and intake should be set by the Licensee on the basis of the expected individual Dose. Values should be a fraction of the relevant Dose Constraint Workers may receive in a monitoring period. The table below contains investigation levels for Occupational Exposures that the Authority finds reasonable. The annual Doses associated with these investigation levels would be about the same as the occupational Dose Constraints recommended above. However, they are based on monthly Doses rather than on annual Doses so that they would be more sensitive to potential overexposures, and as such serve as a tool to verify the conduct of practice with Radiation Sources over time.

Table (3): **Investigation levels for Occupational Exposures the Authority finds Reasonable**

Practice	**Investigation Level for Occupational Individual Dose** **mSv per month**
Industrial radiography, irradiators and accelerators, nuclear medicine, radiotherapy	0.5
Diagnostic radiology, fixed gauges, portable gauges, X-ray security scanners, well-logging	0.3

Practice	Investigation Level for Occupational Individual Dose mSv per month
Hand or finger dosimeter in any practice	5
Female Workers in any practice who are pregnant or breastfeeding	0.1

Worker Dose Limits

Article (9)

1. Article 10 of FANR-REG-24, as amended, sets limits for the Dose to the Worker in planned exposure situations. It requires the Licensee to ensure that the Worker's exposure does not exceed the Dose limits. There are no exceptions.

2. The Authority considers that 'normal exposure' includes exposure from normal work and from any reasonably foreseeable event that may be expected to arise during the course of the practice. Any event where Worker Dose limits are exceeded must be reported to the Authority within 24 hours as required by Article 19 of FANR-REG-24, as amended.

3. For the purposes of compliance with 100 mSv in five years, as defined in Article 10 of FANR-REG-24, as amended, the five-year period starts on 1 January 2018 and ends on 31 December 2022, and continues to repeat in fixed five-year calendar blocks of time.

4. The exposure of an individual Worker should be controlled so that the Effective Dose does not exceed 20 mSv in one year. This includes the external Dose as well as the internal Dose received by the Worker during the period. Where the exposure of an individual Worker results in an Effective Dose exceeding 20 mSv in a year but within the Dose limit of 50 mSv, the management should do the following, as appropriate:

    a) Carry out a review to determine whether exposures were as low as reasonably achievable and take the necessary corrective action where appropriate in accordance with Article 21 of this regulatory guide,

    b) Consider ways to restrict further exposure of the individual Worker to ensure that the Effective Dose over the chosen five-year averaging period is less than 100 mSv,

    c) Notify the Authority of the magnitude of the Dose and the circumstances leading to the exposure.

Public Dose Limits

Article (10)

1. Article 11 of FANR-REG-24, as amended, sets Dose limits for the normal exposure of the public. It requires the Licensee to ensure that the normal exposure of the public does not exceed the Dose limits. There are no exceptions.

2. The Authority takes the view that 'normal exposure' includes exposure from normal work and from any reasonably foreseeable events that can be expected to arise during the course of the practice. Any event where the public Dose limits are exceeded must be reported to the Authority within 24 hours as required by Article 19 of FANR-REG-24, as amended.

3. Licensees often have offices, corridors and other public areas adjacent to rooms in which Ionising Radiation is generated. Licensees must ensure that members of the public in these areas, including the Licensee's staff members who are not radiation Workers, do not receive greater exposure than the public Dose limits provided for in Article 11 of FANR-REG-24, as amended. In order to estimate Doses in these areas, Licensees need to take occupancy factors into account. The occupancy factor is the fraction of time an individual may be expected to occupy a particular area. Using guidance from the National Council on Radiation Protection and Measurements in NCRP 147 [Ref. 4], the Authority recommends using the following occupancy factors when preparing Safety Assessment:

Table (4): **The Occupancy Factors Recommended by the Authority**

Type of Area	Occupancy Factor
Offices, laboratories, pharmacies, reception areas, staff waiting rooms, children' play areas, X-ray rooms, film reading areas, nurses' stations, X-ray control rooms	1
Patient exam and treatment rooms	½ (0.5)
Corridors, patient rooms, staff lounges and rest rooms	1/5 (0.2)
Corridor doors	1/8 (0.125)
Public toilets, vending areas, Storage rooms, outdoor areas with seating, unattended waiting rooms, patient holding areas	1/20 (0.05)
Outdoors, unattended car parks, attics, stairways, unattended lifts, cleaner's cloakrooms	1/40 (0.025)

Protection and Safety Programme

Article (11)

1. Article 12 of FANR-REG-24, as amended, assigns primary responsibility for Protection and Safety to the Licensee and requires implementation of a Protection and Safety programme in order to achieve Protection and Safety when conducing a Licensee's Regulated Activity.

2. The purpose of a Protection and Safety programme is to achieve the protection of the public, Workers, and the environment from Radioactive Material and from activities that produce Ionising Radiation. It should include policies, procedures and organisational arrangements commensurate with the risks.

3. The principal features of a Protection and Safety programme are set out in this article. A thorough description of an occupational Protection and Safety programme can be found in the IAEA Safety Standards on Occupational Radiation Protection, General Safety Guide No. GSG-7 [Ref. 5]. The Authority has also prepared model practice-specific Protection and Safety programmes that Licensees can adopt.

4. It is essential that the Protection and Safety programme begins with a Safety Assessment that includes: 1) an identification of the sources of routine and reasonably foreseeable potential exposures, 2) a realistic estimate of the relevant Doses to Workers, the public, and environment, as applicable, and 3) an identification of the radiological protection measures, including operational as well as investigation levels that are needed to keep Doses below set Dose Constraints.

5. The Protection and Safety programme should include the assignment of responsibilities for occupational Radiation Protection and Safety to the various management levels, including corresponding organisational arrangements. This should include the Radiation Protection Officers and their responsibilities, authorities and access to senior management. It should also include the roles of any Qualified Experts the Licensee has identified, and the Medical Physicist, as appropriate.

6. The Protection and Safety programme should include the designation of Controlled Areas or Supervised Areas as described in Article 21 of FANR-REG-24, as amended. It should include criteria for designating the areas mentioned in the Safety Assessment. Moreover, it should also describe how these areas are monitored, how access to Controlled Areas is restricted, and the protective measures used.

7. The Protection and Safety programme should include or refer to written local rules for Workers to follow and for the supervision of work particularly the procedures associated with Controlled Areas. These rules should be prominently displayed or readily available in the workplace. As appropriate, the Protection and Safety programme should include

policies and procedures for developing detailed work plans and using radiation work permits.

8. The Protection and Safety programme should document the decisions on measures for occupational Radiation Protection and Safety, and any personal protective equipment (PPE) that is used. It should include arrangements for monitoring Workers and the workplace, as appropriate, and the system for recording and keeping up-to-date all relevant information related to the Operation of the Facility and control of exposures, and for reporting all such information to the Authority and other authorities, as appropriate. In particular, the Programme should document the Licensee's policies and procedures for Worker Dose Assessments, including arrangements for dosimetry services, and reporting of occupationally exposed Workers' Doses and inventories of Radiation Sources to the Authority. It should also document the acquisition, calibration and Maintenance of Radiation Protection instruments, and Radiation Sources.

9. The Protection and Safety programme must clearly describe arrangements for the following:

   a) Promptly notifying the Authority of changes in the status of inventory items (e.g. intention to transfer an inventory item to another Licensee, or where an item has been lost or stolen),

   b) Obtaining the Authority's prior approval before any planned changes are made to the inventory,

   c) Declaring as disused any inventory item that is no longer used, and is not intended to be used for the practice for which an Authorisation has been granted (e.g. an X-ray tube separated from a dismantled X-ray generator must be reported in the inventory if it remains in the possession of the Licensee or if it can be energised.),

   d) Obtaining the Authority's approval to change the status of an inventory item to 'Possession Transferred' if the item is to be sold or rented to another Licensee,

   e) Measures to prevent the transfer of Regulated Material or other Regulated Items to or from any Person who does not hold the appropriate Licence for the items or material.

10. The Protection and Safety programme should address record-keeping, including workplace monitoring and Worker Dose Assessment records, identification of Workers with access to Radioactive Material or to Controlled Areas, training records, and equipment Inspection, calibration, and Maintenance records.

11. The Protection and Safety programme should document the Worker's training programme, including general Radiation Protection information and training, training for those Workers directly involved in work with Radiation Sources, and training for Workers who are not

occupationally exposed. Training for Workers directly involved in work with Radiation Sources should include relevant information that emphasises the procedures that are specific to the Worker's job assignment, including the proper use of protective equipment.

12. The Protection and Safety programme should address the Licensee's Emergency Plan. The Emergency Plan must be commensurate with the nature and magnitude of the risk involved and is subject to the approval of the Authority.

13. The Protection and Safety programme should set out the Licensee's Quality Assurance programme for all Regulated Activities involving Radiation Sources commensurate with the magnitude of potential exposures from the sources for which the Licensee is responsible. The Quality Assurance programme must include methods for periodically reviewing and auditing the Licensee's Safety performance, including the performance of the Protection and Safety programme itself with the view to ensure that the Facility, Workers, equipment, and Radiation Sources are fit for purpose.

14. The Protection and Safety programme should describe organisational and financial arrangements for ensuring Radiation Sources are safely managed during operations at the Facility, and at the end of their useful life or termination of operations at the Facility.

15. The Protection and Safety programme should include a Decommissioning Plan for the cessation of operations involving Radioactive Material in accordance with articles 5 and 6 of FANR Regulation on the Decommissioning of Facilities (FANR-REG-21), as amended, and in accordance with the provisions set out in FANR Regulation on the Pre-disposal Management of Radioactive Waste (FANR-REG-26), as amended.

Safety Assessment

Article (12)

1. Article 12 of FANR-REG-24, as amended, refers to a Safety Assessment. A Safety Assessment identifies the sources of routine and reasonably foreseeable potential exposures; it should provide a realistic estimate of the resulting Doses and detailed description of radiological protection measures implemented to keep Doses below Dose Constraints for the public and Workers.

2. In accordance with the IAEA's International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources (GSR Part 3, as amended), a Safety Assessment should include a review of the following:

    a) Nature and magnitude of potential exposures and preferably the likelihood of their occurrence,

    b) Limits and technical conditions for Operation of the source,

c) Ways in which procedures, and structures, systems and components related to protection or Safety might fail singly or in unison, or otherwise lead to potential exposures, and the consequences of such failures.

d) Ways in which operating procedures related to protection or Safety might be erroneous, and the consequences of such errors.

3. A Safety Assessment should provide a basis for deciding the following:

a) The required engineered Safety control measures,

b) The development of procedures to be followed by occupationally exposed Workers,

c) The requirements and procedures for designating Controlled Areas and Supervised Areas,

d) Method and frequency for monitoring of Public Exposure and Occupational Exposure,

e) Any public protection requirements,

f) Information on probable Accidents and Incidents and the measures required to minimise the likelihood of these Accidents and Incidents occurring, and mitigate their impact if they do occur,

g) Information on the actions to be taken to restrict exposure in the event of an Emergency or Incident (Emergency Preparedness Plan).

4. A Safety Assessment should be commensurate with the complexity and the radiation risks of the Licensee's activities. Generic Safety Assessments are usually sufficient for types of sources with a high degree of uniformity in design.

5. The Authority has developed advice on preparing a Safety Assessment and reporting the results with descriptions of postulated scenarios to be addressed in the Safety Assessment. For normal Operation conditions, calculations should consider Dose rates or the committed or absorbed Dose, as appropriate, with and without shielding on the surfaces bordering public areas and at locations where personnel are working. Calculations should identify the shielding material used with the pertaining attenuation or transmission factors based on the output of the inventory item with documented references, distances from the Radiation Source, and occupancy factors for the Representative Person. The Representative Person should include Workers at their work locations, and members of the public close to the surfaces for which the Dose is calculated. Calculations may assume Gy equals Sv. Below is a sample Safety Assessment reporting table, which is acceptable to the Authority:

Table (5): **Safety Assessment Reporting Formats Recommended by the Authority**

Table I. **Dose Constraints**

	mSv/ year	**Technical Explanation** (if Dose Constraints differ to values in Article 6 of this regulatory guide)
Public (0.1 mSv/ year)		
Occupationally Exposed Workers		

Table II. **Description of the worst-case scenario per inventory item type**

Description of radiation application	**Output** (uGy/ hr or Gy)	**Output distance to Radiation Source** (d0), (m)	**Workload per year** (total hours or no. of exposures)

Table III. **Description of shielding characteristics per scenario from Table II**

	Output **(keV)**	***Shielding coefficient,** **(fr or att)**	**Distance to rad. source, **d, (m)**	**Occupancy factor***(OF)** **(frac. of 1 or h)**	**Results for Dose rate or Absorbed Dose**	
					No shielding **(uGy/ hr or uGy)**	**Shielding Thickness to achieve Dose Constraints (cm)**
A					**CA / SA+**	

B						**CA / SA**	

*Reference for attenuation (att) or transmission (fr) factor should be provided with indicated related shielding thickness (Xfr).

**d is the distance from source to location where Occupational Exposure or Public Exposure is expected to occur.

***OF, occupational factor can be taken from Article 9(2)(a) in this regulatory guide.

+ Reference floor layout and indicate if it is a Controlled Area (CA) or a Supervised Area (SA).

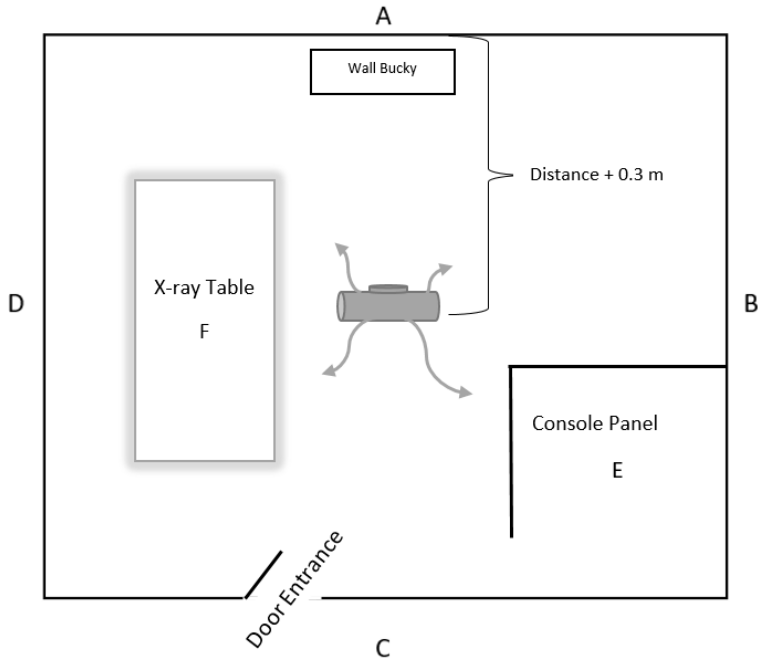
Table IV. **Description of shielding arrangements per scenario from Table II**

Material	**Thickness, X, (mm)**	**Location of application**	**Description of application**

6. For medical radiographic applications, Table II and Table III should be filled in and submitted to the Authority.

Table (6): **Radiographic Applications Safety Assessment Reporting Formats Recommended by the Authority**

Equipment Name:		**Unit Serial No:**	**FANR No:**
MAX KVP:	**MAX mA:**	**Assumption based on Reference from:**	
No. of Patients or No. of Exposures Per Week:			



Spot of Location	Type of Radiation (Primary or Secondary)	Dose Rate without Shielding per week		Shielding Design target per week	Occupancy Factor	Use Factor	Required Shielding	
		Distance (m)	Dose Rate				Material Name	Required Thickness in mm
A								
B								
C								
D								
E								
F								

Door Entrance								

Potential Exposures

Article (13)

1. Potential exposures are exposures that could result from a situation that is feasible but unexpected. Article 14 of FANR-REG-24, as amended, requires that Licensees assess the probability and consequences of potential exposures, their magnitude and the number of people who may be affected by them. Potential exposure becomes an actual exposure situation if the unexpected occurs e.g. as a consequence of equipment failure. Practice-specific examples include the separation of an industrial radiography source from its cable thereby preventing its retraction into the projector; a mobile moisture-density gauge hit by a vehicle; or an Accident involving damage to a ^{99}Mo/^{99}Tc radionuclide generator that results in the release of ^{99}Mo.

2. In order to assess the consequences of potential exposures, Licensees should identify the potential scenarios likely to result in unplanned exposures. These potential scenarios result from equipment failures, human errors such as incorrect procedures or failure to follow procedures or External Events. Scenarios can be identified based on operating experience or other information about Accidents, failures, errors or other events that could lead to potential exposures.

3. Controlling potential exposure requires a combination of good installation design, properly commissioned, calibrated and maintained equipment, and continuously improved operating procedures. These actions have two purposes: first, to restrict the probability of occurrence of events leading to unplanned exposures and second, to limit the magnitude of the exposure that results if such events occur.

Radiation Protection Officers (RPOs)

Article (14)

1. A detailed discussion on the Radiation Protection Officer can be found in section 3.27 to 3.34 of the IAEA Safety Standards Series on Building Competence in Radiation Protection and the Safe Use of Radiation Sources, Safety Guide No. RS-G-1.4 [Ref. 8].

2. A Radiation Protection Officer should be familiar with the work performed by the Licensee, and its organisational infrastructure and working procedures, and should have an understanding of relevant regulatory requirements. The Radiation Protection Officer

should have sufficient authority and access to management to be able to perform his or her Radiation Protection and Radiation Safety duties effectively. The Radiation Protection Officer should also be responsible for organising the necessary training of Workers. He or she should also be the central point of reference within a licensed Facility for all Radiation Protection and Radiation Safety matters, and may carry out or directly supervise contingency plans in the event of an Accident or Incident. The responsibilities and qualifications of a Radiation Protection Officer and the time needed to fulfil his or her duties will depend on the activities of the Licensee. For less complex Radiation Protection situations such as dentistry, the role and qualifications of the Radiation Protection Officer will be less demanding than those of a Radiation Protection Officer working in a radiotherapy facility. The time required to perform the duties of a Radiation Protection Officer will depend on the extent and complexity of the Licensee's Regulated Activities. More than one Radiation Protection Officer may be required to ensure Facility's operation.

3. A description of the roles, education, and training requirements for the Radiation Protection Officer can be found in the national strategy on education and training requirements for expert roles in Radiation Protection (see references 8, 9, 10, 11 and 12). The national strategy, as approved by the Radiation Protection Committee (RPC), which was established in 2011 and is led by FANR, is in line with the relevant international guidance.

4. The Radiation Protection Officer should have sufficient relevant training to effectively supervise work with Radiation Sources in order to ensure compliance with local rules and national regulations, to ensure a suitable response in the event of an Emergency, and to train or organise training for Workers in Protection and Safety. He or she should be able to communicate with all Workers in the Facility. The Radiation Protection Officer should have enough knowledge of the practice to fully understand how the applicable Radiation Protection requirements are properly implemented, and the necessary experience to foresee the potential for Accidents and Incidents. The Radiation Protection Officer should also have the necessary personal attributes (such as communication, leadership and analytical skills) to effectively discharge his or her responsibilities.

5. There are situations where it is recommended to have more than one Radiation Protection Officer. The number of Radiation Protection Officers is decided on the basis of the principle that a Radiation Protection Officer should be fully familiar with the Radiation Protection and Safety of Regulated Activities for which he or she is responsible and capable of addressing all such matters within the scope of their daily work functions and responsibilities. Two broad considerations are important: first, a Licensee engaged in several practices may require a different Radiation Protection Officer for each practice according to the time, specific skills and experience necessary. And second, the Regulated Activities of the Licensee may be undertaken at several locations significantly far apart that it would not be possible for a single Radiation Protection Officer to be familiar with the various locations or have effective oversight on Radiation Protection and Safety at each location.

6. If a Licensee has more than one Radiation Protection Officer, the Authority recommends that the Licensee considers assigning one as the lead or senior Radiation Protection Officer so that the coordination and reporting responsibilities are clear.

7. A technician reporting to a Radiation Protection Officer should have a written job description that clearly documents his or her responsibilities and activities. The technician should be able to demonstrate relevant competences and experience, and be able to perform assigned Radiation Protection and Safety tasks accordingly.

Training

Article (15)

1. The Authority endorses the training recommendations set out by the IAEA, including the use of testing. Job categories for which specific training, testing and periodic re-training should be given, including Qualified Experts, Radiation Protection Officers, occupationally exposed Workers, and qualified Operators. The IAEA splits training in Radiation Protection and Safety into the following areas:

    a) Review of fundamentals,

    b) Quantities and measurements,

    c) Biological effects of Ionising Radiation,

    d) Principles of Radiation Protection and the international framework,

    e) Regulatory Control,

    f) Assessment of internal and external exposures,

    g) Protection against Occupational Exposure,

    h) Medical Exposures in diagnostic radiology, radiotherapy, and nuclear medicine,

    i) Exposure of the public from radiation-related practices,

    j) Intervention in situations of chronic and Emergency exposure,

    k) Training the trainers.

2. Articles 16, 20 and 29 of FANR-REG-24, as amended, require periodic refresher training, as it is important that all Workers refresh and update their skills and knowledge. Refresher training would typically include the following topics:

a) A review of knowledge of Radiation Protection and Safety,

b) Information on changes to policies and procedures for Radiation Safety,

c) Changes to equipment, instrumentation or processes,

d) Results of internal audits or Inspections,

e) New or revised regulations,

f) Feedback from operational experience and good practices,

g) Lessons learnt from Incidents, Accidents or operational failures.

3. Emergency Response planning and training should be proportionate to the risks associated with the practice. Emergency Response training should address the topics set out in the document entitled Training in Radiation Protection and the Safe Use of Radiation Sources, Safety Report Series No. 20 published by the IAEA. Part X of this document on the Intervention in Situations of Chronic and Emergency Exposure includes training on Emergency exposure. Part X contains 10 modules and the IAEA provides more detailed information about each module in its postgraduate course in Radiation Protection and the Safety of Radiation Sources [Ref. 12]. The Authority recommends that Licensees review these parts and determine which are appropriate for their Radiation Protection Officers and Workers depending on each Licensee's circumstances. The Authority considers parts X.1, X.2, and X.5 to apply to Regulated Material. Below is a summary of these parts:

   a) Part X.1 on general principles and types of events: nuclear and radiological Accidents, Accidents with Radiation Sources, history of past Accidents, and lessons learnt.

   b) Part X.2 on basic concepts for Emergency Response: concepts and objectives of Emergency Response, principles of intervention, including intervention levels, protective actions and operational intervention levels, Emergency Response strategies, and the generic response organisation.

   c) Part X.5 on the overview of Assessment and response in a radiological Emergency: Accident scenarios, generic response organisation in a radiological Emergency, Emergency management, response at the scene such as co-ordination of organisations involved, initial response, radiological response such as source recovery, decontamination, removal of Radioactive Waste, Dose Assessment, and lessons learnt from the Goiania Accident.

4. Licensees should consider these parts as guides, and include additional information in their training, as appropriate. For example, lessons learnt from the IAEA reports on the Accidents in San Salvador, in Hanoi, and in Tammiku should be considered.

5. When a Licensee has established appropriate Emergency Response training, it should be documented in the Licensee's Emergency Plan. Emergency Response training should include drills, exercises and refresher training. The Authority recommends that Licensees conduct practice drills at least twice each year and that all employees involved in Emergency Response participate.

6. The Radiation Protection Officer should have sufficient skills and experience to ensure a suitable response in the event of an Emergency, and to provide Emergency Response training to the Workers.

Qualified Experts

Article (16)

1. The Authority does not certify Qualified Experts, but relies on other competent bodies for certification as described in the Radiation Protection Committee's national strategy for education and training of experts in Radiation Protection. The national strategy is in line with the IAEA Safety Standards Series on Building Competence in Radiation Protection and the Safe Use of Radiation Sources No. RS-G-1.4 [Ref. 8] and provides a detailed discussion of Qualified Experts in section 3.20 to 3.26. Its principal points are set out in Article 16 of this regulatory guide.

2. Qualified Experts provide advice on (and/ or conduct activities) in their field of specialisation. Individual Qualified Experts are unlikely to have expertise in all areas but will probably be specialised in certain topics.

3. A Qualified Expert will have had a formal education up to (and including) a university degree or equivalent diploma in science or engineering. Qualified Experts should have a thorough knowledge of specific topics related to their field of expertise and should keep up-to-date with developments in that field. Qualified Experts should also have extensive work experience in relevant areas to have the competence to understand new and complex situations, and to give direction and guidance for solving problems.

4. Article 14 of FANR-REG-24, as amended, requires Licensees to identify roles and responsibilities of the Qualified Expert for the Operation of a Facility, and to identify by name recognised Qualified Experts according to the Radiation Protection Committee's national strategy for education and training of experts in Radiation Protection.

Safety Culture

Article (17)

1. Article 13 of FANR-REG-24, as amended, requires Licensees to foster and maintain a strong Safety Culture. The said article provides also for specific actions that a Licensee must take in order to accomplish this. In order to build a strong Safety Culture, Licensees are encouraged to explicitly recognise their primary responsibility for Safety by doing the following:

    a) Formally requiring each of their employees to comply with all the Authority's regulations, regulatory guides and the Law [Ref. 13].

    b) Provide organisational arrangements and lines of communication that result in an appropriate flow of information on Protection and Safety at all levels in the Licensee's organisation.

    c) Ensure that the Licensee's employees understand and assume their responsibility for their own Safety and the Safety of others around them. Licensees are responsible for providing all equipment, procedures and training necessary to ensure Safety. Employees are responsible for using the equipment properly, following the procedures, learning from the training, and being accountable for their actions and decisions.

    d) Encourage employees to raise Safety issues and respond constructively when they do, and provide ways for employees to raise Safety issues in addition to informing other supervisors in case their own supervisor is not receptive.

    e) When an employee raises a Safety issue, the management should respond in a timely way and inform the employee of what has been done. The management does not need to agree with the employee, but it does need to give every potential Safety issue its serious consideration and tell its employees what actions it has taken or plans to take.

    f) Licensees should also take great care to ensure that their follow-up to Incidents such as overexposure is just and that their employees understand that the Licensee is being fair. In particular, Licensees should consider how their follow-up actions might affect the behaviour of employees. Here is a scenario: a Licensee terminates an employee because he or she has received an overexposure. The Licensee's other employees then stop wearing their dosimeters to avoid the same consequences if they too were to receive a Dose higher than expected. In this case, the Licensee should have investigated and identified the causes of the overexposure, and taken all necessary measures to prevent its recurrence (including further Worker training as necessary). Then the Licensee should have

reported its actions to the Authority, and explained to its Workers how these actions have improved Safety and further limited the risk to themselves. In this way Safety Culture is strengthened rather than damaged.

Manager Training

Article (18)

Senior managers should be trained in the risks associated with Ionising Radiation, the basic principles of radiation protection, their main responsibilities regarding radiation risk management, the principal elements of the Protection and Safety programme, and the importance of a Safety Culture and how to implement it.

Licensee's Responsibility for Protection and Safety

Article (19)

1. Article 14 of FANR-REG-24, as amended, requires Licensees to establish and implement necessary arrangements to ensure the Protection and Safety of the Covered Activity for which they are licensed. The Licensee must specify roles and responsibilities for Protection and Safety for all jobs in its organisation at all levels across the organisation. Organisational arrangements for the conduct of the Covered Activity should specify the supervisory and reporting structure in the organisation.

2. The Authority requires that Licensees make Workers aware of their immediate responsibility for Protection and Safety.

3. The Licensee's management is responsible for defining Workers' roles and responsibilities, and ultimately making sure that Protection and Safety rules as depicted in the Licensee's Protection and Safety programme are observed in the Operation of the Facility.

4. The Licensee may appoint Qualified Experts to support the conduct of the Covered Activity in the Facility, and is expected to contract appropriate service providers in the field of Radiation Safety. Service providers will provide a service such as calibration and Maintenance of the equipment, shielding calculations, individual monitoring for Workers, and education and training in Radiation Protection or similar that is not commonly the scope of expertise of the Facility's staff but is required as per the Authority's regulations.

5. In order to ensure observing Protection and Safety during the Operation of the Facility, the Licensee is expected to:

a) Assess the extent and impact of the consequences of potential exposures on Workers and the environment based on the Safety Assessment results.

b) Establish a periodic review of Protection and Safety with a view to assess the suitability of the Protection and Safety programme for everyday operations of the Facility, and the effectiveness of the programme's implementation.

c) Ensure expert roles and services are available as needed during the Operation of the Facility.

d) Account for the experience obtained by implementing concepts of operational experience as required in Article 17 of FANR-REG-24, as amended, and by monitoring for compliance as required in articles 25 and 26 of FANR-REG-24, as amended, to ensure the quality of Facility's operations.

Accident Prevention

Article (20)

1. The Authority recommends that Licensees take the following actions to reduce the likelihood of Accidents:

a) Ensure that there are no gaps in the staff member's authority and responsibility that could result in Safety-critical tasks being insufficiently covered.

b) Select equipment and implement approved procedures to the extent practical so that no single equipment failure or single human action should disable a Safety function, and implement the concept of Defence-in-Depth.

c) Ensure that Safety procedures in the Protection and Safety programme are clear, and are sufficiently detailed and comprehensive, and that they are properly documented and readily available in the language(s) Workers understand; the Workers must be fully trained in the use of the procedures.

d) Ensure Workers are appropriately qualified and trained with the necessary educational background and specialised training appropriate to the practice.

e) Train Workers to be alert to Accidents and to their onset, and to respond promptly and properly should they occur.

f) Maintain working conditions that minimise distractions.

Evaluation of Overexposures

Article (21)

1. Article 19 of FANR-REG-24, as amended, requires Licensees to report to the Authority any event where a Dose limit is exceeded within 24 hours of the discovery. Where there is uncertainty, the Licensee should promptly seek guidance from the Authority. Licensees should act promptly to prevent further overexposure and to preserve information that may be important in the investigation of the cause.

2. If an overexposure occurs, Article 17 of FANR-REG-24, as amended, requires that the Licensee conducts a formal investigation as soon as possible after the event and produces a written report on its cause with a verification or determination of any Doses received, and recommendations for preventing the recurrence of similar events.

3. The main points of an investigation on overexposure can be summarised in the steps below, which must be followed even if a formal root cause evaluation has to be done:

    a) Identify what Radioactive Material or source of radiation was involved. Explain what the state was, before, during and after the event. Get documentation to confirm the strength of the source.

    b) Identify the individuals involved. Get names and the locations of all involved individuals, including bystanders and members of the public. The Licensee will need to determine who was exposed and by how much.

4. Establish a timeline for the event(s); Who was where and when? For external exposures, determine the distance from the Radiation Source to all involved individuals. This includes bystanders and anyone who may have been exposed. Estimates may have to be made for unidentified individuals, for example, an industrial radiography source left in an unshielded position may have exposed an individual walking by. Identify all used and unused PPE, if available.

5. Collect all dosimeters to promptly determine the external Dose. Do the same for air samplers and records for recording area monitors. If radiation detectors such as Geiger-Mueller survey meters were involved in the event, have them collected and recalibrated as soon as possible to determine their accuracy and ability to function properly.

6. For internal uptakes, initiate a bio-assay. If a gamma emitter was involved, a whole body count will be needed. It is possible to use medical scanning cameras for whole body counting on an ad-hoc basis.

7. Interview each individual involved separately. Determine where they were, their actions and the actions of other individuals to the degree relevant, and record interviews with concerned individuals. For those with either an active role in the event or a supervisory

responsibility, ask the reasons for their actions. For example, if surveys were not done determine why they were not. Estimate how well a supervisor did his or her job.

8. Reconstruct the Dose from the known source and reconcile with available measurements. For example, if an industrial radiographer shows a dosimeter with an exposure of 100 mSv, assess if this is consistent with the radioactivity of the source being used, the radiographer's location(s) and the length of time the source was exposed. Estimate from the time, distance, shielding and source strength the exposure of all concerned individuals. As applicable, evaluate airborne releases similarly.

9. Determine the cause of the event. For most events, the source was left in an unshielded position and either the proper surveys were not done or radiation readings were ignored. This could be caused by failure to follow proper procedures, lack of training, equipment failure or carelessness. For generators, the causes can be more complicated; equipment may be improperly used or operated in an unexpected fashion.

10. Assessed Doses close to Dose limits are unlikely to require more than an investigation of the causes, so the appropriate lessons can be learnt. They do not require special medical investigations or treatment. Only at Doses higher than the Dose limits will special Dose investigations involving biological dosimetry, like chromosomal aberration analysis in somatic cells and further extended diagnosis or medical treatment, be necessary.

11. When it is suspected that Doses received are close to or above the thresholds for deterministic effects, the investigation should determine as accurately as possible the absorbed Doses and their distribution over the body, and should include appropriate medical examinations of the affected Worker(s).

12. In addition to the above, medical Licensees are required by Article 41 of FANR-REG-24, as amended, to investigate any treatment or radionuclide administration to the wrong patient, the wrong tissue, with the wrong pharmaceutical, or a Dose or Dose fractionation differing substantially from the values prescribed by the medical practitioner. The Authority recommends interpreting as more or less than 20% of the total prescribed Dose for diagnostic applications, and more or less than 10% of the total prescribed Dose for radiotherapy applications [Ref. 15]. Licensees must also investigate any equipment failure, Accident, error, mishap or other unusual occurrence with the potential to cause a patient exposure to be significantly different from that intended. They must report the results of these investigations to the Authority and relevant health authorities.

13. Medical Licensees are also required to conduct a review if typical Doses or activities for a given radiological procedure exceed or fall substantially below relevant Diagnostic Reference Levels.

Abnormal Circumstances

Article (22)

1. Article 17 of FANR-REG-24, as amended, requires that Licensees conduct formal investigations of abnormal circumstances that arise while operating Facilities or conducting activities, and provide the Authority as soon as possible with any information significant to Protection and Safety. A formal investigation of an abnormal circumstance should be comparable to an investigation of an overexposure, as described in Article 21 of this regulatory guide. At a minimum, the formal investigation of an abnormal circumstance should include the following:

    a) Identification of the Radioactive Material, radiation generators and equipment involved,

    b) Names and locations of all involved individuals, including bystanders and members of the public,

    c) Separate interviews with each individual involved,

    d) Description of the event(s) in detail including, a detailed timeline,

    e) Description of the immediate and root cause(s) of the event,

    f) Lessons learnt and corrective actions to be taken,

    g) Description of the entire investigation.

Inventory and Number of Sources That May be Stored in One Place

Article (23)

1. When the Authority grants a Licence, it sets a limit on the total radioactivity and the total number of sources the Licensee may possess. The Authority does not set a limit on the number of the sources that may be stored in a single place or at a single location. However, the Licensee must meet the Safety and security requirements that correspond to the total radioactivity that may be stored there. That is, the Authority's requirements will apply to the total radioactivity the Licensee is authorised to store. If the total radioactivity that the Licensee is authorised to store is as much as an IAEA Category 1, 2 or 3 source, that Licensee must meet the Authority's Safety and security requirements for an inventory of that size.

2. The Licensee must keep an inventory under control of all Radiation Sources in its possession, and must ensure information on the inventory is readily available at locations

where Radiation Sources are used or handled. The inventory must be kept on a server that is under the Licensee's control. Inventory information should allow tracking of the location of the Radiation Sources by time, and enable an estimate of potential hazards to Workers, the public or the environment.

3. The Licensee should restrict access to the inventory. Only trained and specialised staff would have access to the inventory in order to perform everyday tasks such as Maintenance or calibration, accountancy or similar. Inventory access by identified personnel should be job-related, based on client request and order, or instruction from a supervisor. Similarly, access to Radiation Sources used in medical applications should only be available to staff members qualified to operate or handle such sources, and experts or service providers requiring access to the sources for Maintenance, calibration, audit or similar activities. Patients, carers, visitors or other non-staff members should not be able to access Radiation Sources either intentionally or by Accident.

4. A specified Radiation Source may be rented or otherwise temporarily acquired from another Licensee only if the Licence of the recipient already authorises possession or use of the specific Radiation Source. Furthermore, the Licensee must not make the transfer before obtaining the Authority's approval. Approval will be given only as confirmation of the recipient Licensee's request to change the status of the Radiation Source to 'custody transfer'. While renting the source, the recipient Licensee is also responsible for making sure the source is in a good working condition and is compatible with auxiliary equipment that may also be used to perform a specific job.

5. The Licensee must not transfer a Radiation Source to another Licensee without first obtaining firm evidence that the source will be in the possession of, or for use or handled by a Licensee with the appropriate authorisation from the Authority.

Radiation Warning Signs and Labels

Article (24)

1. For many years the internationally recognised Ionising Radiation symbol has been the trefoil as shown below.

2. When Licensees use this symbol, it should have the same shape, colours and orientation as shown.

3. In 2007 the IAEA and the International Organization for Standardisation (ISO) announced a new Ionising Radiation symbol [Ref. 16] that looks like this:

4. The original trefoil as shown above in Article 24(1) has been (and will continue to be) located on access doors such as to X-ray rooms, transportation packages, and containers.

5. The new symbol as shown above in Article 24(3) is attached directly to IAEA Category 1, 2 and 3 sources (i.e. dangerous sources capable of death or serious injury). Such sources include food irradiators, teletherapy machines for cancer treatment and industrial radiography units. The new symbol is placed directly on the device housing the source as a warning not to dismantle the device or to get any closer. It should not be visible in normal use, but revealed only if someone attempts to disassemble the device. The new symbol should not be used on access doors, transportation packages or containers. The original trefoil from Article 24(1) here above will continue to be used on the IAEA Category 4 and 5 sources.

6. The inappropriate use of radiation labels such as on empty containers or the frivolous use of these labels can cause confusion and degrade their significance when they are used when actually required. Thus, the Authority discourages these practices.

Health Surveillance

Article (25)

1. According to articles 20, 24 and 26 of FANR-REG-24, as amended, the Licensee should ensure that all Workers engaged in activities in which they could be subject to Occupational Exposure are provided with the necessary Workers' health surveillance and health services. For itinerant Workers who are subject to Occupational Exposure, Facility management should make special arrangements with the employer of the contracted Workers to ensure that they are provided with the necessary Workers' health surveillance.

2. The occupational health services should have the following responsibilities in relation to Workers' health surveillance:

    a) Assessment of the Workers' health.

    b) Compatibility between the health of Workers and their conditions of work.

    c) Creation of a record that provides useful information in the case of:

        i. Accidental exposure or occupational illness,

        ii. Statistical evaluation of the incidence of illnesses that might relate to the working conditions,

        iii. An assessment for public health purposes of management in relation to Radiation Protection and Safety in Facilities in which Occupational Exposure can occur,

        iv. Medical or legal enquiries.

    d) Provision of counselling for Workers on any radiation risks to which they might be subjected, and an advisory and treatment service in the event of personal contamination or overexposure.

3. The occupational physician in charge of the programme for Workers' health surveillance should have the following responsibilities:

    a) To carry out medical examinations on Workers.

    b) To advise management periodically on the fitness of Workers for their intended tasks, on the basis of the Worker's state of health and the employer's requirements for the job.

    c) To give Clearance for the return of Workers to their normal working environment after being removed from that environment on medical grounds.

    d) To advise, as appropriate, on the arrangements for hygiene at work and the removal of contamination from wounds in consultation with the Qualified Expert, as appropriate.

4. The occupational physician including, any private occupational physician employed on a part-time basis should be knowledgeable through training and re-training where necessary on the biological effects of radiation exposure, the means of control of exposure, and the interpretation of exposure data and dosimetric assessments. With the support of specialists, as appropriate, the occupational physician should be in a position to use this

knowledge in the programme for Workers' health surveillance and also to provide counselling to the following categories of Workers with regard to radiological health risks:

a) Occupationally exposed female Workers who suspect that they are pregnant or who may become pregnant, or who are breastfeeding,

b) Individual Workers who have received, or who may have received, an exposure substantially in excess of the Dose limits,

c) Workers who may be worried about their radiation exposure,

d) Workers who otherwise request such counselling.

5. In order to be able to make judgements about Workers' fitness for work, the occupational physician should be familiar with the tasks in the workplace and the conditions in the working environment.

6. The occupational physician should take responsibility for case management in the event of a suspected overexposure. This should include submission of details of the case to relevant Qualified Experts, the counselling of the Worker, and the briefing of Workers' representatives and the Worker's family members, if appropriate.

7. Medical examinations of workers should be performed before the start of employment, periodically thereafter and at the termination of employment.

8. A medical history and assessment should be established for each Worker for the following purposes:

a) To determine fitness for the specific work for which the Worker is to be employed,

b) To provide a baseline for use in the consideration of changes to specific work practices,

c) To provide a baseline for use in assessing an occupational disease or overexposure.

9. The initial medical examination should be aimed at assessing the Worker's health and fitness for the intended tasks and identifying whether the Worker has a condition that might require special precautions during work. However, it should be rare for the radiation component of the working environment to influence significantly the decision about the fitness of a Worker to undertake work with radiation, or to influence the general conditions of service. The medical conditions that the occupational physician should look for include those which would affect the ability to use and wear protective clothing and equipment, the ability to hear alarms and respond to radiation hazards, and the ability to use specialised tools and equipment.

10. Fitness for work with radiation depends on the Worker's state of health and the type of work involved as illustrated by the following examples:

    a) If a Worker's duties require the use of respiratory protective equipment, the occupational physician should examine fitness of the Worker to wear respiratory protective equipment including, checks on the integrity of lung function.

    b) If a Worker is engaged in the handling of unsealed Radioactive Material, fitness for work could be influenced by the presence of skin conditions such as eczema or psoriasis. In such cases, the decision regarding fitness should be based on the nature, extent and evolution of the skin condition, and the nature of the job. Workers with such skin conditions should not necessarily be excluded from work with unsealed radioactive substances if the levels of radioactivity are low, provided that appropriate precautions, such as covering the affected parts of the body, are taken.

    c) If a Worker is required to work with Radioactive Material, fitness for work could be influenced by a psychological disorder. In such cases, the decision on fitness should take account of the Safety implications of symptomatic episodes of such a disorder. The primary concern is whether such Workers could represent a danger to themselves or to their co-workers or to the public.

11. There is no inherent reason why a Worker who has previously undergone radiotherapy should be excluded from work with radiation. Each case should be evaluated individually by taking into account the outcome of the radiotherapy treatment, the general prognosis and other health considerations, the understanding and wishes of the Worker, and the nature of the work.

12. In the periodic medical examinations, the occupational physician should confirm that no clinical condition that could prejudice the health of the Worker has developed during work in areas involving occupational health hazards, including hazards due to radiation. The nature of a periodic medical examination should depend on factors such as the type of work that is undertaken, the age and health state, and possibly the habits of the Worker (e.g. smoking habits). For example:

    a) The skin should be examined where the nature of the work creates a potential for localised skin damage from exposure particularly of the hands.

    b) A Worker who has already received accumulated Doses to the lens of the eye of more than 0.5 Gy, or who could after a few more years accumulate Doses in excess of this level may need to be subject to regular ophthalmological examination. This relates to the risk of detectable opacities and visual impairment, which might affect the ability of the Worker to carry out the intended tasks e.g. performing image-guided interventional procedures.

13. The frequency of periodic medical examinations should be based on the state of health of the Worker and on the type of work involved. Exposure to radiation should not in itself be a reason to carry out periodic medical examinations more frequently than usual.

14. On completing a medical examination, the occupational physician should communicate the conclusions in writing to both the Worker and the employer. These conclusions should not contain information of a medical nature but should at least categorise the Worker as one of the following:

    a) Fit for work in a specific job or trade,

    b) Fit for such work with certain restrictions e.g. no work necessitating respiratory protective equipment,

    c) Unfit for the work in question.

15. With regard to Article 25(14)(c) above, the occupational physician should have the authority to declare Workers temporarily or permanently unfit on medical grounds for their regular work or to recommend the transfer of a Worker to other work. The occupational physician should also have the authority to advise the employer on reinstating such Workers in their normal duties on medical grounds.

16. In the case of an observed ailment likely to have been caused by prevailing working conditions, the occupational physician should advise the management of the need to investigate the working conditions. Where appropriate, the management should take corrective actions in consultation with the occupational physician.

17. Workers should be encouraged to promptly report any significant ailment to the occupational physician.

18. Workers should report to their supervisor and the Radiation Protection Officer any actual or suspected accidental exposure to Ionising Radiation to themselves or others. The occupational physician should be informed if it is suspected that an exposure exceeds a limit set by the Authority and should be advised of the outcome of any investigation to establish whether such an Exposure has actually occurred. The occupational physician may be made part of the proceedings for the investigation of the overexposure.

19. Health surveillance records should be stored according to national regulations on a time-scale similar to that for Dose records as defined in Article 26(1) and (2) of FANR-REG-24, as amended.

20. The exposed Worker should receive medical attention that is appropriate for the Doses that they may have received. Screening based on equivalent Doses to specific radiosensitive organs as a basis for medical follow-up and counselling should be provided if an accidentally exposed Worker received an Effective Dose exceeding 100 mSv over a period of a month or

if the Worker so requests. Although an Emergency Worker or an accidentally exposed employee who receives Doses in a nuclear or radiological Emergency should not be precluded from incurring further Occupational Exposure, qualified medical advice should be obtained before allowing further Occupational Exposure where a Person has received an Effective Dose exceeding 200 mSv. Such advice should also be made available at the request of the Worker. Such qualified medical advice is intended to assess the continued health and fitness of the Worker.

21. More detailed information can be found in Technical and Ethical Guidelines for Workers Health Surveillance [Ref. 17].

Engineered Controls, Administrative Controls and Personal Protective Equipment

Article (26)

1. Article 21 of FANR-REG-24 establishes a hierarchy of methods for achieving Protection and Safety. Engineering controls are preferred over administrative controls and administrative controls are preferred over the use of PPE.

2. Engineered controls are engineered features that do not require human involvement to achieve protection. Examples are shielding, firewalls, and interlocks that prevent doors from being opened or equipment from being operated until necessary Safety conditions have been met.

3. Administrative controls are specifications for human actions that are necessary to maintain safe conditions. Examples include procedures, warning signs and work permits.

4. PPE consists of items worn or carried by an individual to achieve protection. Examples include protective clothing, respiratory protection, lead aprons and alarming dosimeters.

Controlled Areas and Supervised Areas

Article (27)

1. A Controlled Area should be physically delineated to the extent possible. This means physical boundaries to the Controlled Area and signs and notices at all access points clearly stating the area is controlled. In order to avoid uncertainties about the extent of Controlled Areas, the boundaries should follow physical structures such as walls and doors [Ref. 9]. Where there are no such physical boundaries, a clear system of delineating the area must be used.

2. As an example, in a radiology Facility all X-ray rooms where exposure takes place should be designated Controlled Areas. Areas where mobile X-ray units are used should be categorised as Controlled Areas during the time in which radiological work is being carried out. To the extent possible, the room in which the mobile X-ray unit is located should be designated as the Controlled Area.

3. Specific areas adjacent to X-ray rooms may be designated as Supervised Areas where access is limited to those who comply with pertaining Safety rules and have due cause to enter. A typical design of a radiology department includes two basic areas: a staff area and an area for patients. Most of the staff area may be classified as a Supervised Area not because of the exposure level, which can be kept very low, but because of the potential for other individuals inadvertently entering the X-ray rooms and receiving an exposure.

4. In relation to radiotherapy, the treatment room would normally be designated a Controlled Area. The treatment control area and other areas adjacent to the treatment room might also be designated Controlled Areas if the Facility operation cannot be organised such that Dose levels in these areas are sufficiently low to be considered as Supervised Areas [Ref. 18].

5. When designating Controlled Areas and Supervised Areas, Licensees should take into account the public Dose Constraints in Article 7 of this regulatory guide and the occupancy factors in Article 10 of this regulatory guide.

6. In relation to nuclear medicine, the rooms for preparation, Storage and administration of radiopharmaceuticals should be Controlled Areas. Due to the potential risk of contamination, imaging rooms and waiting areas should also be Controlled Areas. Areas should also be designated Controlled Areas where patients are in the presence of other patients who have been given therapeutic amounts of a radiopharmaceutical. In the case of beta emitters such as ^{90}Y, ^{89}Sr or ^{32}P, which are not excreted from the body, the patient area may not need to be classified as a Controlled Area. The room for temporary Storage of Radioactive Waste should be a Controlled Area. It may be pragmatic to classify the whole nuclear department as a Supervised Area due to the risk of contamination.

7. In relation to industrial radiography onsite, radiography should be carried out in an area designated as a Controlled Area. No other work should be permitted in this area until the radiography has finished and the Controlled Area is no longer thus designated. The boundary of the Controlled Area should be set to ensure that possible Doses to people outside the Controlled Area are below relevant reference Dose levels. These levels should depend on factors, including how the radiography will be conducted and the occupancy of areas at or near the Controlled Area boundary. The Authority recommends using values in the range of 2.5–20 μSv/ hour depending on the occupancy factor.

Personal Protective Equipment

Article (28)

Article 22 of FANR-REG-24, as amended, requires Licensees to ensure that Workers are provided with PPE. The Authority has developed the following examples as a guide for this equipment. Licensees should consider the types and energies of radiation and contamination that may be present, and select the appropriate equipment.

Table (7): **Examples of the Equipment Workers should be Provided with**

Practice	Examples of Personal Protective Equipment
Diagnostic radiology	Lead equivalent apron/gonad shield for patient. All staff out of the Controlled Area or behind a shielded console. For fluoroscopy cases, lead equivalent aprons, goggles and tableside scatter shields, thyroid shields, and lead flaps for staff.
Dental X-ray	All staff out of the Controlled Area or behind a shielded console.
Brachytherapy	For manual brachytherapy, long-handled forceps, lead gloves, lead aprons, and goggles, portable shields, lead screens, and thyroid shields.
Teletherapy	All staff to be out of the room or at shielded console.
Cardiac Catheterisation	Portable shields, lead aprons, lead screens and goggles, flaps and curtains, lead gloves and thyroid shields.
Lithotripsy	All staff to be out of the room or at shielded console. Otherwise, lead aprons, thyroid shields, lead goggles, and lead flaps for staff.
Fixed gauges	Not used
Industrial radiography	Not used
Large-scale irradiator	Not used
Nuclear medicine	Protective eyewear for personnel involved with the treatment of patients who have received therapeutic Doses. Gloves and protective clothing such as laboratory coats and boots for personnel working with unsealed sources. Syringe shields for radiopharmaceuticals and transparent lead shields for the radiopharmaceutical preparation area. Fume hoods, as appropriate.
Portable gauges	Not routinely used. Gloves and overalls should be available.
Well-logging	For unsealed tracers: gloves, overalls, respirators, and face shields.

Practice	Examples of Personal Protective Equipment
X-ray security scanners	Not used

Dosimetry

Article (29)

1. Article 24 of FANR-REG-24, as amended, requires that Licensees provide individual monitoring for any Worker normally employed in a Controlled Area, or occasionally working in a Controlled Area and who may receive significant Occupational Exposure. The Authority also recommends individual monitoring for any Worker likely to receive more than 10% of the annual Dose limit of 20mSv in any one year. For most cases individual monitoring means that Workers must wear personal dosimeters.

2. Licensees must assess the Occupational Exposure of any Worker regularly employed in a Supervised Area or who enters a Controlled Area on occasion. However, this may be done on the basis of workplace monitoring so that personal dosimeters for these Workers are not required.

3. In order to ensure that personal dosimeters are always worn in Controlled Areas and to avoid the risk of dosimeters being mislaid, the Authority recommends that Workers who are required to wear personal dosimeters routinely wear them throughout the working day. Licensees should store the dosimeters of off-duty employees in one location along with a control dosimeter from the dosimetry service.

4. In most cases a single dosimeter worn on the torso is adequate. The side of the dosimeter facing the body should be consistent with the provider's instructions so the body does not inadvertently shield the dosimeter. For strongly penetrating radiation, the dosimeter should be placed in a position at which the highest exposure on the surface of the trunk is expected. For radiation coming primarily from the front, or when the exposure to radiation is expected to be rotationally symmetrical or isotropic, the dosimeter should be worn on the front of the torso between the shoulders and the waist. Dosimeters to assess Doses to the lens of the eye should be worn near the eyes (e.g. on a cap or on the forehead). In situations where there may be significant accidental radiation exposures such as industrial radiography in addition to ordinary dosimetry, alarming dosimeters should be worn.

5. In order to improve the measurement of an Effective Dose received in a non-homogeneous radiation field, it is useful for Workers to wear additional dosimeters on other parts of the body. In some situations, (e.g. medical radiology) where protective clothing such as lead-equivalent aprons are used, the Authority recommends the use of one dosimeter under the protective apron worn at waist level, and one outside the apron on an unshielded part

of the body usually on the torso at collar or shoulder level. The purpose of the two dosimeters is to determine the Effective Dose received by the shielded and unshielded parts of the body. If only one dosimeter is available, it must be worn beneath the apron.

6. For cases where the maximum Dose to extremities is expected to be at least ten times greater than the Dose to the surface of the whole body, one or more extremity dosimeters should be worn in positions that will measure Dose to the area(s) expected to receive the highest Dose. For example, when working with radiopharmaceuticals, the use of extremity dosimeters such as ring dosimeters should be considered.

7. Dosimeters tend to be read on a monthly basis. For some low-Dose situations, quarterly readings are acceptable. General Licence Conditions require that Licensees report twice a year the radiation Dose that each of its Workers has received during the previous six months. Minimum parameters for reporting Occupational Exposure data can be found in Annex A of this regulatory guide.

8. The Authority recommends that Licensees assign personal dosimeters to individuals using both the wearer's full name and a unique identification number (e.g. Emirates ID or passport number), and that they use the full names and unique identification numbers when the dosimeters are sent to laboratories for reading. The use of full names reduces the likelihood that the Doses reported by a laboratory will be allocated to the wrong Person. The unique identification number prevents confusion if two Persons have the same name.

9. Similarly, Licensees should enter the full names of Workers into Dose and health surveillance records to assist the Authority in constructing the lifetime Dose record of an individual occupationally exposed whilst being an employee or contractor of more than one employer. Further details on reporting Occupational Exposures to a national database maintained by the Authority can be found in Annex A of this regulatory guide.

10. Article 24 of FANR-REG-24, as amended, requires that Licensees use approved or licensed dosimetry services. At present, the Authority is developing dedicated regulatory framework for provision of services in the field of radiation protection. For the time being the Authority does not accredit dosimetry services. Instead, the Authority relies on formal approval by recognised radiological health authorities, including approval by the Health and Safety Executive in Great Britain (HSE), accreditation by the National Voluntary Laboratory Accreditation Programme in the United States of America (NVLAP), or successful participation in IAEA inter-comparisons. Licensees wishing to use other dosimetry services formally approved by other organisations should contact the Authority to learn whether it accepts approvals by that organisation.

11. The Authority has initiated the development of a Secondary Standards Dosimetry Laboratory to perform dosimetry accreditation, and it is developing regulatory requirements to approve dosimetry service providers.

12. When dosimeters have been lost or damaged, the Dose may be estimated in several ways. Licensees should use the method that best fits their circumstances, and include the reasons for using that method in the documentation of the estimate. If appropriate, more than one method may be used; four acceptable methods are shown below [Ref. 9].

    a) The previous Dose history of the individual in question:

       The dosimetry history of a Worker reporting a lost or damaged dosimeter is reviewed by the Radiation Protection Officer. An official Dose is assigned based on an average from previous monitoring periods or the highest Dose recorded during his or her employment.

    b) The Dose received by a co-Worker performing similar tasks:

       The Radiation Protection Officer assigns a Dose to the individual based on the Dose received by a co-Worker who performed similar tasks during the monitoring period in question.

    c) Known or estimated Dose rates and occupancy times:

       The Radiation Protection Officer assigns a Dose based on known area Dose rates and estimates the time spent by the individual in such an area or areas.

    d) The highest Dose received by a co-Worker during the period in question:

       The Dose assigned to the individual in question is equivalent to the highest Dose received by a co-Worker during the monitoring period in question.

13. Licensees should have a written procedure to estimate Doses in the case of a lost or damaged dosimeter. If a dosimeter is lost or damaged, Licensees should document how the Dose was estimated as well as the actions taken to prevent dosimeters from being lost or damaged in future.

Monitoring, Survey Instruments and Dosimeters

Article (30)

1. Licensees must monitor potential radiation exposure and contamination using instruments and dosimeters appropriate for their practice. Licensees should develop monitoring programmes and select instruments and dosimeters appropriate to the types and energies of radiation and contamination that may be present. Licensees using accelerators should consider the potential for pulsating fields and select monitoring instruments unaffected by such fields. Licensees should measure contamination using instruments that measure radioactivity per surface area rather than the Dose rate. In situations where an immediate

warning of high Dose rates or high Doses is required (e.g. industrial radiography), alarming dosimeters should be worn in addition to the conventional dosimeter.

2. The Authority recommends that Licensees use the table below as a guide.

Table (8): **Examples of the Licensees' Monitoring Program Elements**

Practice	Workplace Monitoring	Survey Meter	Individual Monitoring
Diagnostic radiology	Not used	Not used	Personal dosimeter[1]
Dental X-ray	Not needed	Not used	Not used or 10% evaluation[2]
Brachytherapy	Radiation monitor to indicate radiation levels in the treatment room, or perform area surveys before and after treatment	Survey instrument capable of locating low energy gamma or beta seeds such as I-125 or Pd-103 that might not have been implanted at the beginning of therapy or removed at the end of it.	Personal dosimeter
Cyclotron	Gamma sensing radiation monitor with an audible alarm	Meter capable of detecting gamma at levels as low as 0.1 micro Sv per hour. Meter capable of measuring neutron radiation, as appropriate.	Personal dosimeter, including neutron dosimeter as appropriate
Teletherapy	Permanently mounted beam-on radiation monitor with a visible alarm and	Meter capable of detecting gamma at levels as low as 0.1 micro Sv per	Personal dosimeter, including neutron

[1] Personal dosimeters appropriate for energy, type of radiation, and type of Dose to be detected such as direct ion storage (DIS), electronic personal dosimeter (EPD), optically stimulated luminance (OSL), thermoluminescent dosimeter (TLD), or film badges for gamma radiation; neutron badges where needed.

[2] A 10% evaluation is a documented evaluation by the Licensee that a Worker is not likely to receive more than 10% of the annual occupational Dose limits in Article 10 of FANR-REG-24, as amended. This evaluation can be done on the basis of prior experience such as Doses measured by the Licensee or Doses measured by others in similar situations, area surveys, or a calculation based on source strength, distance, shielding, and time spent in the work area.

Practice	Workplace Monitoring	Survey Meter	Individual Monitoring
	an independent emergency power supply	hour. Meter capable of measuring neutron radiation, as appropriate.	dosimeter, as appropriate
Cardiac catheterisation	Not used	Not used	Personal dosimeter, finger ring dosimeter
Interventional radiology	Not used	Not used	Personal dosimeter, finger ring dosimeter
Lithotripsy	Not used	Not used	Personal dosimeter
Fixed gauges	Not used	Meter needed only for non-routine operations such as installation, relocation, removal or non-routine maintenance. Meter should be able to measure gamma radiation from 0.1 micro Sv per hour to 2 mSv per hour	Personal dosimeter or 10% evaluation
Industrial radiography	Not used	Meter should measure gamma radiation from 0.1 micro Sv per hour to 10 mSv per hour.	Alarming personal dosimeter plus personal dosimeter
Large-scale irradiator	Gamma sensing radiation monitor with an audible alarm	Meter should be able to measure gamma radiation from 0.1 micro Sv per hour.	Personal dosimeter
Nuclear medicine	Perform daily contamination surveys of all areas where unsealed Radioactive Material is used, including	Pancake Geiger-Mueller counter or other low-range detector capable of detecting alpha and beta contamination.	Personal dosimeter, finger ring dosimeter

Practice	Workplace Monitoring	Survey Meter	Individual Monitoring
	areas where patients injected with a radiopharmaceutical can cause contamination.		
Positron emission tomography (PET)/ computed tomography (CT)	Gamma sensing radiation monitor with an audible alarm	Meter should be able to measure from 0.1 micro Sv per hour to 0.5 mSv per hour.	Personal dosimeter
Portable gauges	Not used	Licensees should have access to a survey meter that detects gamma radiation from 0.1 micro Sv per hour to 0.5 mSv per hour, and neutron radiation. Licensees should also have access to leak testing capability.	Personal dosimeter or 10% evaluation
Well-logging	Not used	Meter should be able to measure from 0.1 micro Sv per hour to 0.5 mSv per hour, and neutron radiation if neutron sources are used.	Personal dosimeter plus neutron sensitive dosimeter if neutron sources are used, or 10% evaluation
X-ray security scanners	Not used	Meter needed only for non-routine operations such as installation or non-routine maintenance	Personal dosimeter or 10% evaluation

3. A discussion of types of monitors and dosimeters can be found in the IAEA's Practical Radiation Technical Manual on Workplace Monitoring for Radiation and Contamination.

4. Article 25 of FANR-REG-24, as amended, requires that equipment be calibrated at appropriate intervals. The Authority considers this to mean the calibration frequency recommended by the manufacturer. If the manufacturer has not recommended a calibration frequency, then annual calibration will be acceptable.

Worker Compensation for Radiation Exposure

Article (31)

Article 28 of FANR-REG-24, as amended, prohibits Licensees from using compensation as substitutes for providing the required Protection and Safety measures. The Licensee has prime responsibility for the Protection and Safety of Workers, the public and the environment. This responsibility cannot be diminished or delegated and the risk of exposure cannot be transferred to employees. For this reason, compensation for such risk is contrary to the UAE law and international standards. Moreover, Licensees must not offer already exposed Workers compensation in the form of benefits such as monetary payments. This direction is to prevent Workers from deliberately receiving exposures in order to qualify for compensation.

Female Patients who are Pregnant and Breastfeeding

Article (32)

1. In line with international best practice, the Authority recommends that a pregnant woman should not be subject to any diagnostic or therapeutic procedures with a radioactive substance unless the application is lifesaving. Detailed information is available in Appendix IV of the IAEA Safety Report Series No. 40 on Applying Radiation Safety Standards in Nuclear Medicine [Ref 13].

2. Interventional fluoroscopically guided procedures may give foetal Doses in the range of 1 mGy to 100 mGy depending on the procedure (e.g. interventional procedures of pelvis area). If the expected or delivered foetal Dose is above 1 mGy, a detailed explanation and Dose assessment is needed.

Female Workers During and After Pregnancy

Article (33)

1. For the purposes of occupational Radiation Protection, there is no reason to make any general distinction between Workers on the basis of gender. However, additional Radiation Protection measures are required to be considered for a female Worker during and after pregnancy in order to protect the embryo or foetus or the breastfed infant.

2. The following Exposure pathways to the embryo or foetus or the breastfed infant are of potential concern:

    a) In utero:

        i. External exposures due to Radioactive Material outside of the body of the female Worker, which irradiates not only maternal tissue but also the embryo or foetus.

        ii. Internal exposures due to the incorporation of radionuclides by the female Worker (or radionuclides present in hollow organs such as the bowel or bladder) that transfer to the foetus through the placenta, or Exposure of the foetus to penetrating radiation from radionuclides deposited in maternal tissues (or those present in hollow organs).

    b) Breastfed infant:

        i. External exposures due to penetrating radiation from radionuclides in maternal tissue or present in hollow organs such as the bladder or bowel.

        ii. Internal exposures from the intake of radionuclides by the breastfed infant transferred from maternal tissue to breast milk and subsequently ingested during breastfeeding.

3. The Licensee's management is required to provide female Workers who are likely to enter a Controlled Area or a Supervised Area, or who may undertake Emergency duties with appropriate information on the risk to the embryo or foetus or their breastfed infant during and after pregnancy. Such Workers cannot be compelled to notify the Licensee's management if they are breastfeeding, or are (or suspect that they are) pregnant. Nonetheless, the Licensee's management is required to inform female Workers of the importance of notifying their employer as soon as possible so that the working conditions in respect of Occupational Exposure can be modified accordingly to protect the embryo or foetus or their breastfed infant.

4. Once a female Worker who is likely to enter a Controlled Area or Supervised Area, or who may undertake Emergency duties notifies the Licensee that she is (or suspects she is) pregnant, or that she is breastfeeding, the Licensee is required to adapt the working conditions in respect of Occupational Exposure so as to ensure that the embryo or foetus, or the breastfed infant is afforded the same broad level of Radiation Protection as is required for members of the public. It is required that such notification should not be considered a reason to exclude the female Worker from work, but would require more stringent restrictions on the Occupational Exposures to which the female Worker is subject. The Licensee should inform the female Worker of the decision to apply more stringent restrictions.

5. The more stringent restrictions should not necessarily prevent the female Worker from working with radiation or Radioactive Material, or from entering or working in designated radiation areas. However, the restrictions should be intended to ensure that under normal operational conditions the requirements of FANR-REG-24, as amended, with regard to Dose limits for members of the public are met for the embryo or foetus during pregnancy, and for the breastfed infant thereafter. Furthermore, the adapted working conditions should be such as to avoid any significant potential exposure due to Accidents or other unforeseen events that could result in high radiation Doses from internal exposure or external exposure.

6. In determining more stringent Dose restrictions, account should be taken of any Doses that were received by the embryo or foetus as a result of the female Worker's Occupational Exposure to external radiation in the period between conception and notification of pregnancy. Account should also be taken of any Doses that were (or that will be) received by the embryo or foetus or by the breastfed infant as a result of any intakes of radionuclides by the female Worker prior to the notification of pregnancy, including intakes prior to conception.

7. The employer should consider whether the female Worker needs further information and training as a result of any change of working conditions to restrict exposure of the embryo or foetus or of the breastfed infant.

8. As a result of the more stringent restrictions on Dose, female Workers should be monitored during and after pregnancy. Doses should be assessed with account taken of all relevant pathways of internal exposure and external exposure.

9. Once the Worker has notified the Licensee of her pregnancy or having a breastfed infant, the monitoring programme should be re-defined so as to be able to determine that the estimated Dose to the embryo or foetus or the breastfed infant (including the Dose from intakes by the female Worker prior to conception) that could be due to Occupational Exposure will not exceed 1 mSv. Modification of the monitoring programme for internal exposure might be necessary because some radionuclides might be of more relevance for foetal Doses than for maternal Doses.

10. If there are indications that the Dose to the embryo or foetus or the breastfed infant might approach 1 mSv/ year, individual monitoring of the female Worker and individual assessment of the committed Dose to the embryo or foetus or the breastfed infant should be carried out. Dose reports should be available quickly to allow for prompt action to be taken if it is found that the Dose to the embryo or foetus or the breastfed infant might exceed 1 mSv/ year.

11. A shorter period (i.e. greater frequency) of monitoring may be advisable to keep closer control over possible inadvertent exposures. However, this frequency should be chosen in

consideration of the recording level of the passive dosimeter or other techniques used. For dosimeters with a recording level of 0.1 mSv, a monitoring period of less than one month might not be long enough to evaluate adequately the Dose to the foetus during the whole period after the notification of pregnancy. An active dosimeter might serve the purpose of maintaining alertness to any possible accidental exposures. In all cases, the Dose recorded for the pregnant female Worker should be that of her regular dosimeter.

12. The calibration of dosimeters should be considered in assessing Doses to the embryo or foetus. For radiation fields of penetrating radiation, dosimeters that have been calibrated for the personal Dose equivalent Hp(10) will give an overestimation of the Dose. However, this may not be the case for radiation fields of high energy neutrons or of particles in accelerator facilities for which dosimeters calibrated for Doses at different depths below the surface are required.

13. Although it is not required to use an additional dosimeter on the abdomen, it can provide reassurance that attention is being given to any Exposure during pregnancy. The Licensee should consider the use of an appropriate dosimeter to monitor the Dose to the foetus. If the external radiation is homogeneous, there is no preferred position on the abdomen for the dosimeter, but if the radiation field is inhomogeneous, the dosimeter should be positioned on that part of the abdomen that might be irradiated more significantly.

14. In the case of a suspected accidental intake, special monitoring should be carried out to ensure that the Dose limit for the embryo or foetus or for the breastfed infant will not be exceeded. Monitoring may be carried out by using whole body counting, individual organ counting (such as thyroid counting or lung counting) or in vitro analysis of the female Worker's excretions.

15. In the assessment of external Dose to the foetus, only penetrating radiation should be considered. In the case of homogeneous radiation fields for photons and beta radiation, the Dose recorded by the female Worker's dosimeter will be a conservative estimate of the Dose to the foetus because by the time the Worker has notified the Licensee of her pregnancy, the Dose at the depth of the foetus should be lower. In the case of inhomogeneous fields, a careful assessment of the dosimeter's results and the corresponding Dose to the foetus is necessary.

Medical Quality Assurance

Article (34)

1. Article 38 of FANR-REG-24, as amended, includes requirements on Quality Assurance for medical Licensees.

2. The Authority recommends that Quality Assurance requirements for therapeutic uses of radiation are fulfilled by (or under) the supervision of a medical physicist. For diagnostic and image-guided interventional uses of radiation, the Quality Assurance requirements should be fulfilled by a Medical Physicist, or under their oversight, or upon their documented advice where the degree of involvement of the Medical Physicist is determined by the complexity of the particular use of radiation and the ensuing radiation risks.

3. A medical Licensee's Quality Assurance programme should include the following:

    a) Procedures (i.e. patient's signs and symptoms, and history, diagnostic particulars, appropriateness of investigations and contraindications).

    b) Procedure planning (i.e. reliable administrative procedures, patient information and patient preparation).

    c) Clinical procedures (i.e. approved suppliers and materials, Storage, radiopharmaceutical preparation, clinical environment, patient handling and preparation, performance of equipment, acquisition protocol and waste Disposal).

    d) Training and experience of nuclear medicine specialists, physicists and technologists and others involved.

    e) Data analysis (i.e. processing protocol, performance of equipment, data accuracy and integrity).

    f) Reports (i.e. data, image review, results and further advice).

    g) General outcomes (i.e. clinical outcome, radiation Dose, patient satisfaction and referring physician satisfaction).

    h) Periodic audits of the programme's performance including independent audits.

4. A Quality Assurance Programme for Radiation Sources should do the following:

    a) Require that sealed and unsealed sources or devices used for Medical Exposure be purchased only from manufacturers or distributors approved by the regulatory authorities in their country of manufacture.

    b) Require that a detailed description of Maintenance and service arrangements be provided with all equipment. This is especially important since a proven, safe design alone is not sufficient to ensure Safety throughout the useful life of the equipment. The vendor or manufacturer should be selected only if it guarantees that spare parts and Maintenance will be provided for a reasonable period of time.

c) Require that equipment be tested and maintained on the schedule recommended by the manufacturer, or on an annual basis; whichever is most frequent.

d) Require that the recipient ensures that quality control tests have been carried out on donated equipment before agreeing to accept it. The report of the quality control tests should be included with the application for the import or reinstallation of the equipment. Further quality control tests should be made on the equipment after installation but before its first clinical use.

e) Require that the supplier demonstrate compliance of the refurbished equipment with appropriate standards by carrying out appropriate tests.

f) Require quality control tests to be performed following any Maintenance and before clinical application.

g) Require the identification and measurement of the radioactivity of all radioactive drugs prior to their administration to each patient or human research subject.

h) Require the establishment of procedures on Quality Assurance for all sources, equipment, systems and accessories that are:

I. Used to deliver a Medical Exposure.

II. Involved in obtaining diagnostic images (i.e. gamma cameras, film processors and image intensifiers).

III. Used for planning of treatment in radiotherapy.

i) Require testing of sealed sources for leakage at regular intervals as recommended by the manufacturer.

j) Require regular physical inventories of all Radiation Sources at the intervals established by the Authority.

5. The Quality Assurance programme for instrumentation for calibration and clinical dosimetry should provide for the regular calibration of each instrument in accordance with international standards or applicable national requirements.

6. The Quality Assurance of each instrument should begin with the selection and acquisition of the instrument itself since instruments may differ widely in their performance.

7. The choice of an appropriate laboratory for the calibration of an instrument should similarly be considered within the scope of Quality Assurance. A recommended procedure is:

a) Once received, an instrument should be subjected to a series of acceptance tests designed to establish whether its initial performance conforms to the

manufacturer's specifications. At the same time, reference tests should be carried out to provide data against which its subsequent performance can be assessed by routine testing at regular intervals.

b) Operational checks should be performed each day that the instrument is used. Careful records of all the tests should be kept and, if these reveal unsatisfactory performance, appropriate action should be taken. Such Quality Assurance is not a substitute for the need for preventive Maintenance procedures, which should be carried out on a regular basis.

c) Tests should also be carried out following any Maintenance.

8. The Authority's recommendations for Quality Assurance programmes mentioned in this article are derived from the IAEA Safety Standards on Radiation Protection and Safety in Medical Uses of Ionizing Radiation, Specific Safety Guide No. SSG-46, 2018 [Reference 9]. Detailed information on Quality Assurance for teletherapy and brachytherapy devices is also available in the IAEA publication on Radiation Oncology Physics: A Handbook for Teachers and Students, Vienna, 2005 [Reference 19].

Decision to Hospitalise or Discharge a Patient

Article (35)

1. The Authority considers that patients may be discharged from a medical Facility when the estimated Dose to a member of the public will be less than 1 mSv per year or the estimated Dose to a caregiver or member of the family will be less than 5 mSv during the period of the patient's treatment. The Dose to a pregnant woman is further limited on the basis that the foetus is generally regarded as a member of the public and thus has an independent limit of 1 mSv per year. It may be appropriate to place restrictions on infants and children to keep their Doses under 1 mSv per year.

2. Should the patient die in the period immediately following therapy, special consideration may need to be given to the treatment of the corpse. The patient's relative or someone else who is responsible for the corpse should be given details of patient's treatment and contact details for a Radiation Protection expert or Medical Physicist associated with the department responsible for radiotherapy. In cases where the death occurs in a hospital, access to the room occupied by the deceased should be controlled until the room has been decontaminated and surveyed. Radioactive corpses should be identified as a potential hazard. A body bag may need to be used to contain leakage of radioactive substances. In order to minimise external radiation risk, the corpse may need to be retained in a clearly delineated radiation Controlled Area, and its transfer to the mortuary or burial ground may need to be controlled.

3. The Authority endorses the guidance in the IAEA Safety Report Series No. 63 on the Release of Patients After Radionuclide Therapy [references 3 and 4].

Annex A – Minimum Parameters for Reporting Occupational Exposure Data

Licensee

Information	Required (Yes/ No)	Notes or Required Format
Licensee's name	Yes	
Licence number	Yes	
Licensee's address	Yes	
Licensee's phone number	Yes	
Licensee's e-mail	Yes	
Approved dosimetry service (ADS) provider's name	Yes	
ADS primary identification number	Yes	
ADS address	Yes	
ADS phone number	Yes	
ADS e-mail	Yes	

Worker

Information	Required (Yes/ No)	Notes or Required Format
First name	Yes	
Middle name(s)/ initial	Yes	
Last name	Yes	
Birth date	Yes	dd-month in words-yyyy
Gender	Yes	Male, Female

Pregnant female Worker	Yes	Yes, No, N/A
Declaration of pregnancy	Yes	dd-month in words-yyyy, N/A
Revocation of pregnancy	Yes	dd-month in words-yyyy, N/A
Declaration of breastfeeding	Yes	dd-month in words-yyyy, N/A
Revocation of breastfeeding	Yes	dd-month in words-yyyy, N/A
Conclusion of pregnancy	Yes	dd-month in words-yyyy, N/A
Nationality	Yes	Country, N/A
Identification number	Yes	
Identification type	Yes	Enter the type of ID: Emirates ID Passport number Work permit number Other
Occupation/ activity	Yes	Enter the type of occupation/ activity: Nuclear Emergency Worker Industrial Medicine Research Government Private Naturally occurring Radioactive Material (NORM) Miscellaneous

Dose

Information	Required (Yes/No)	Notes or Required Format
Record/ estimate	Yes	
Routine/ planned special exposure/ Emergency – Accident	Yes	
Monitoring period	Yes	dd-mm-yyyy to dd-mm-yyyy
External Dose *Hp*(0.07)	Yes	For the monitoring period in Sv/mSv/µSv
External Dose *Hp*(10)	Yes	For the monitoring period in Sv/mSv/µSv
Internal Dose	Yes	For the monitoring period in Sv/mSv/µSv
Effective Dose	Yes	For the monitoring period in Sv/mSv/µSv
Effective Dose annual total	Yes	Total for the current year in Sv/mSv/µSv
Effective Dose five-year total	Yes	Total for the current five-year period in Sv/mSv/µSv
Organ Dose[3]	Yes	For the monitoring period in Sv/mSv/µSv
Lens (eye) Dose[1]	Yes	For the monitoring period in Sv/mSv/µSv
Lens (eye) annual Dose[1]	Yes	Total for the current year in Sv/mSv/µSv
Lens (eye) five-year total[1]		Total for the current five-year period in Sv/mSv/µSv

[3] Dose will be provided if separate than the whole body Dose.

Extremity Dose[1]	Yes	For the monitoring period in Sv/mSv/µSv
Extremity annual Dose[1]	Yes	Total for the current year in Sv/mSv/µSv (Include which extremity)
Dose correction – Period	Yes	dd-mm-yyyy to dd-mm-yyyy
Dose correction Dose value	Yes	Sv/mSv/µSv

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Article (36)

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