United Arab Emirates

الهيئة الاتحادية للرقابة النووية
Federal Authority for Nuclear Regulation

Regulatory Guide

Pre-disposal Management of Radioactive Waste (FANR-RG-018)

Version 0

Federal Authority for Nuclear Regulation (FANR)

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United Arab Emirates

FANR
الهيئة الاتحادية للرقابة النووية
Federal Authority for Nuclear Regulation

Table of Contents

Basic Principle of Regulatory Guides

Regulatory Guides are issued to describe methods and/ or criteria acceptable to the Federal Authority for Nuclear Regulaiton (FANR) for meeting and implementing specific requirements in FANR's regulations. Regulatory guides are not substitutes for regulations and compliance with them is not required. Methods of complying with the requirements in regulations different from the guidance set forth by regulatory guides can be acceptable if the alternatives provide assurance that the requirements in the regulations are met.

Definitions

Article (1)

Except for Representative Person as defined in below consistent with FANR-REG-24 all the capitalised terms used in this regulatory guide are defined in FANR Regulation for Pre-Disposal Management of Radioactive Waste (FANR-REG-26) or in the Federal Law by Decree No 6 of 2009, Concerning the Peaceful Uses of Nuclear Energy (i.e. the Nuclear Law).

Representative Person: an individual receiving a dose that is representative of the more highly exposed individuals in the population.

Purpose

Article (2)

1. This is a regulatory guide to assist FANR's Licensees conducting activities involving the pre-disposal management of Radioactive Waste, including spent and disused sealed sources associated with the use of Radioactive Material in medicine, industry, research, agriculture and education as well as Waste arising from the Operation of Nuclear Facilities.

2. The regulatory guide addresses the following requirements of FANR regulations:
   - the authorisation of Discharges to the environment and Discharge control measures (Articles 30(3) and 30(4) of FANR-REG-24 Revision 1; Article 23 of FANR-REG-11)
   - the characterisation and classification of Radioactive Waste (Article 16 of FANR-REG-11 and Article (5) of FANR-REG-26)
   - generation of Radioactive Waste (Article 15 of FANR-REG-11; Article 30(2) of FANR-REG-24 Revision 1; and Article (4) of FANR-REG-26)
   - Treatment and conditioning of Radioactive Waste (Article (17) of FANR-REG-11 and Article (6) of FANR-REG-26)

- storage of Radioactive Waste (Article (18) of FANR-REG-11 and Article (7) of FANR-REG-26)
- Safety Assessment and the Safety Case (Article (20) of FANR-REG-11 and Article (9) of FANR-REG-26)
- record-keeping (in support of the above mentioned requirements)

3. Annexes A-C provide specific guidance for the pre-disposal management of:
   - Dis-used sealed sources
     - Of low radioactivity (≤100 MBq) (Annex A1)
     - Of higher radioactivity (>100 MBq) (Annex A2)
   - Laboratory and medical Wastes (Annex B)
   - Residues from Industrial Processing (Annex C)

Discharges

Article (3)

Licensees may discharge Radioactive Material into the environment only if the Radioactive Material has been given Clearance in accordance with Article 6 of Basic Safety Standards for Facilities and Activities involving Ionising Radiation other than in Nuclear Facilities (FANR-REG-24) Revision 1 or Articles 22 and 23 of FANR Regulation for Radiation Protection and Pre-disposal Radioactive Waste Management in Nuclear Facilities (FANR REG-11); or in accordance with an authorised Discharge permit included as a part of the Licence.

1. A Discharge permit will be issued by FANR, taking into acccount any necessary approvals by local competent authorities, on the basis of a demonstration by the Licensee (or the Licence applicant) that the planned Discharge of Radioactive Waste into the environment:
   - has been subject to a process of Optimisation of Protection and Safety, taking into account the overall management of Radioactive Waste in the licensed Facility or Activity
   - the Dose to the Representative Person arising from the Discharge does not exceed the public Dose constraint proposed by the Licensee and agreed to by the Authority

2. When applying for a Discharge permit, the Licensee needs to:

   - determine the characteristics and radioactivity of the Radioactive Material to be discharged, and the potential points and methods of Discharge;

   - determine all significant exposure pathways by which discharged radionuclides can deliver Public Exposure;

- assess the Doses to the Representative Person due to the planned Discharges.

3. The submission should also address the issues of Waste generation and management interdependences. In this regard, the submission should demonstrate that Licensees will ensure that the generation of Radioactive Waste, in terms of activity and volume, is kept to the minimum practicable and that available options for Waste Disposal are taken into account to ensure that Discharge to the environment is an acceptable option. Therefore, different possible operational regimes will need to be considered in the submission, together with their associated Discharge levels and any anticipated fluctuations during normal Operation.

4. In making the submission to the Authority for a Discharge permit, more detailed regulatory guidance is provided in IAEA Safety Standard No WS-G-2.3: Regulatory Control of Discharges to the Environment, paragraphs 3.10 to 3.35, with the following qualifications:

   - Dose to the Representative Person should be applied, rather than the Dose to the Critical Group; and
   - the Dose constraint should be proposed by the Licensee and approved by the Authority.

5. At this time, the Authority does not seek to have a separate environmental impact evaluation (that is, an evaluation of the radiological impact of Discharges on flora and fauna is not required).

Characterisation and Classification

Article (4)

1. Radioactive Waste is required to be characterised at the various stages in its Pre-disposal management to obtain information on its properties for use in controlling the quality of the products, verifying the process and thus facilitating the subsequent steps for safely Processing and finally disposing the Radioactive Waste.

2. The data requirements for characterisation and methods for collecting data will differ depending on the type and form of the Radioactive Waste. When Waste streams are processed, characterisation may be performed by sampling and analysing the chemical, physical and radiological properties of the Waste. The quality of Waste Packages may be investigated by non-destructive and by destructive methods. However, it may be possible to apply indirect methods of characterisation, based on process control and process knowledge either instead of or in addition to sampling and the Inspection of Waste Packages in order to avoid undue Occupational Exposure.

3. An important objective of the Pre-disposal management of Radioactive Waste should be to produce Waste Packages that can be handled, transported, stored and disposed of safely. In particular, Radioactive Waste should be conditioned to meet the acceptance requirements for its Disposal. In order to provide reasonable assurance that the conditioned Waste can be accepted for Disposal, although there may not yet be any specific requirements, options for the future management of Radioactive Waste and the associated Waste acceptance requirements should be anticipated as far as possible. The Waste acceptance requirements may be met by providing an overpack that is tailored to the specific conditions at the repository site and to the characteristics of the Radioactive Waste and the engineered components of the Disposal Facility. Annex II of the IAEA Predisposal Management of Low and Intermediate Level Radioactive Waste Safety Guide (WS-G-2.5) provides a listing of the typical properties and characteristics that should be considered for Waste Packages in the Pre-disposal management of Radioactive Waste.

4. In order to support the acceptance of Waste Packages for Disposal, a programme should be established to develop a process for Conditioning that is approved by the Authority and is consistent with Waste acceptance criteria in currently internationally adopted or envisaged Disposal options. The features adopted for Waste characterisation and process control should provide confidence that the properties of Waste Packages will be ensured.

5. For the purposes of consideration of Waste Disposal options and to aid communication about Waste management, Licensees should classify their Radioactive Waste holdings taking into account the scheme established in IAEA Safety Standard GSG-1: Classification of Radioactive Waste. The Waste classes established by this international classification scheme, as adopted by the Authority, are as follows:

   a. **Exempt Waste (EW*)***: Waste that meets the criteria for Clearance or Exemption from Regulatory Control for Radiation Protection purposes as described in FANR-REG-24 (Revision 1)
   b. **Very short-lived Waste (VSLW):** Waste that can be stored for decay over a limited period of up to a few years and subsequently approved for Clearance by the Authority, for uncontrolled Disposal, use or Discharge. This class includes Waste containing primarily radionuclides with very short half-lives often used for research and medical purposes.
   c. **Very low-level Waste (VLLW)**: Waste that does not necessarily meet the criteria of EW, but that does not need a high level of containment and isolation and, therefore, is suitable for Disposal in near surface landfill type Facilities with limited Regulatory Control. Such landfill type Facilities may also contain other hazardous Waste. Typical Waste in this class includes soil and rubble with low levels of activity concentration. Concentrations of longer lived radionuclides in VLLW are generally very limited.
   d. **Low level Waste (LLW):** Waste that is above Clearance levels as established in FANR-REG-24 (Revision 1), but with limited amounts of long-lived radionuclides. Such Waste requires robust isolation and containment for periods of up to a few

hundred years and is suitable for Disposal in engineered near surface Facilities. This class covers a very broad range of Waste. LLW may include short-lived radionuclides at higher levels of activity concentration, and also long lived radionuclides, but only at relatively low levels of activity concentration.

e. **Intermediate level Waste (ILW):** Waste that, because of its content, particularly of long-lived radionuclides, requires a greater degree of containment and isolation than that provided by near surface Disposal. However, ILW needs no provision, or only limited provision, for heat dissipation during its Storage and Disposal. ILW may contain long-lived radionuclides, in particular, alpha-emitting radionuclides that will not decay to a level of activity concentration acceptable for near surface Disposal during the time for which institutional controls can be relied upon. Therefore, Waste in this class requires Disposal at greater depths, of the order of tens of metres to a few hundred metres.
f. **High level Waste (HLW):** Waste with levels of activity concentration high enough to generate significant quantities of heat by the radioactive decay process or Waste with large amounts of long-lived radionuclides that need to be considered in the Design of a Disposal Facility for such Waste (such as spent nuclear fuel, if it is declared as waste). Disposal in deep, stable geological formations usually several hundred metres or more below the surface is the generally recognised option for Disposal of HLW.

6. Further details about this Waste classification are available in the IAEA Safety Standard GSG-1: Classification of Radioactive Waste.

7. Licensees may also classify Radioactive Waste for operational purposes, but it should be possible to broadly relate the operational classifications to the classes in (5) above.

Generation of Radioactive Waste

Article (5)

1. The generation of Radioactive Waste cannot be prevented entirely but it should be kept to the minimum practicable as an essential objective of Radioactive Waste management. Waste minimisation relates to both volume and activity and to both the Waste generated by an initial undertaking and the secondary Waste resulting from the Pre-disposal management of Radioactive Waste. The chemical characteristics of the Waste should also be controlled at the source to facilitate the subsequent Processing of the Waste.

2. Useful strategies for Waste minimisation include:

(a) Reducing the volume of Radioactive Waste to be managed, by adequate segregation and by keeping non-Radioactive Material out of controlled areas to prevent contamination;
(b) The proper planning of activities and the use of adequate equipment for handling Waste so as to control the generation of secondary Waste;
(c) The decontamination of material, together with the control of secondary Waste arising from decontamination;
(d) The recycle and re-use of materials and structures, systems and components.

3. Radioactive Waste should be reduced at source as the most efficient method for Waste minimisation. Consideration should be given to the Design of the Facility and to operational features for Waste minimisation, including the following aspects:

   (a) The careful selection of materials, processes and structures, systems and components for the Facility;
   (b) The selection of Design options that favour Waste minimisation when the Facility is eventually decommissioned;
   (c) The use of effective and reliable techniques and equipment;
   (d) The containment and packaging of Radioactive Material to maintain its integrity;
   (e) The decontamination of zones and equipment and the prevention of the spread of contamination.

Treatment and Conditioning of Radioactive Waste

Article (6)

1. The Treatment of Radioactive Waste may include:
   a. The reduction in volume of the Waste (by incineration of combustible Waste, compaction of solid Waste and segmentation or disassembly of bulky Waste components or equipment);
   b. The removal of radionuclides (by ion exchange for liquid Waste streams and filtration of gaseous Waste streams);
   c. Change of form or composition (by chemical processes such as precipitation, flocculation and acid digestion as well as chemical and thermal oxidation);
   d. Change of the properties of the Waste.

2. Incineration of combustible solid Radioactive Waste normally achieves the highest volume reduction as well as yielding a stable Waste form. After combustion, radionuclides from the Waste will be distributed between the ash, the products from cleaning the exhaust gases and the stack Discharges. The distribution will depend on the Design and operating parameters of the incinerator and the nature of the radionuclides in the Waste. Incineration is also an advantageous technique for treating radioactive organic liquids because the products of complete combustion are ash, carbon dioxide and water. Other

constituents in the Waste may yield acid gases and corrosive combustion products, and the effects of corrosion of the incinerator's components and of acid releases to the atmosphere should therefore be considered. Off-gas scrubbing to prevent the Discharge of radioactive and non-radioactive hazardous materials may be necessary and should be considered. Attention should be paid to radionuclides accumulating in residues of the gas cleaning system and those remaining in the ash, and to their further Conditioning.

3. Releases of radionuclides to the environment are largely determined by the operational conditions of the incinerator, in particular through control of the temperature and the types and amounts of Waste incinerated and its radionuclide content. For incinerators Processing significant amounts of Radioactive Waste, the Operator should monitor the radionuclides in the stack Discharge by appropriate measures to ensure that the concentrations and amounts discharged are within the limits specified by the Authority and are consistent with the parameters modelled in the Safety Assessment and taking into account any policies and requirements of the local competent authority. The products of incineration can include acids, polychlorinated biphenyls and various other materials presenting non-radiological hazards, which should be taken into account.

4. Compaction is a suitable method for reducing the volume of certain types of Waste. The characteristics of the material to be compacted and the desired volume reduction should be well defined and controlled. Consequences of compaction that should be given consideration in selecting or designing and operating a compactor include the following:

   a. The possible release of volatile radionuclides and other airborne radioactive contaminants;
   b. The possible release of contaminated liquid during compaction;
   c. The chemical reactivity of the material during and after compaction;
   d. The potential fire and explosion hazards due to pyrophoric or explosive materials or pressurised components.

5. Segmentation or disassembly and other size reduction techniques may be used before Conditioning Waste that is bulky or oversized in relation to the intended processing (e.g. worn out components or structures). Processes to achieve this typically use cutters with high temperature flames, various sawing methods, hydraulic shearing, abrasive cutting and plasma arc cutting. Means of preventing the spread of particulate contamination should be considered in the choice of method and in the operation of the equipment.

6. For non-combustible and non-compressible solid Waste, for which delay and decay or decontamination is not a viable option, direct Conditioning without prior Treatment should be considered. Melting Radioactive Waste metal scrap, with resultant homogenisation of the Radioactive Material and its accumulation in the slag, may be considered as a means of achieving authorised re-use or removal of Regulatory Control.

7. Methods for the Treatment of aqueous Waste include evaporation, chemical precipitation, ion exchange, filtration, centrifugation, ultrafiltration, electrodialysis, incineration and

reverse osmosis. In each case, process limitations due to corrosion, scaling, foaming and the risk of fire or explosion in the presence of organic material should be carefully considered, especially with regard to the safety implications of operations and Maintenance. If the Waste contains fissile material, the potential for criticality should be evaluated and eliminated to the extent practicable by means of Design features and administrative features.

8. Spent ion exchange resins are usually flushed out as a slurry and subsequently managed as liquid Waste, although some Operators retain the resins as a dry solid. When resins are slurried, care should be taken to prevent blockages of the flow as these may cause radiation hot spots and necessitate special maintenance. Special care should also be taken with their prolonged Storage while awaiting Conditioning, because of the potential for radiolytic or chemical reactions generating combustible gases or causing physical degradation or exothermic reactions.

9. Liquids for Discharge may be produced as a consequence of the Treatment of Radioactive Waste. All discharged liquids should be readily dispersible in water. If the liquid contains suspended materials, it may need to be filtered prior to Discharge. Waste that is immiscible with water should be completely excluded from Discharge. Acidic or alkaline liquids should be neutralised prior to Discharge. If the Waste also contains toxic or other chemicals that could adversely affect the environment or the Treatment of sewage, the Waste should be treated prior to Discharge in accordance with the regulations in respect of health and Safety and environmental protection.

10. Radioactive particulates and aerosols in gaseous effluents may be removed by filtration using high efficiency particulate air (HEPA) filters. Iodine and noble gases can be removed by filters or sorption beds charged with activated charcoal. The use of scrubbers for the removal of gaseous chemicals, particulates and aerosols from offgases should be considered. Where the reliability of the system is fundamental to the achievement of Safety, redundant systems such as two filters in sequence should be used in case one fails. Additional components of the off-gas system that should be considered for detecting problems include those that ensure proper operation of the filters, such as prefilters or roughing filters, and temperature and humidity control systems, as well as monitoring equipment such as gauges that show pressure differentials.

11. Used filters and sorption beds are considered to be solid Waste. The physical and chemical properties of the selected filter masses should therefore be compatible with the Treatment and Conditioning processes for the solid Radioactive Waste streams in which they will be treated. Care should be taken to ensure that the trapped radioactive substances are not dispersed in an uncontrolled manner during the replacement of the filters or the subsequent Treatment of radioactive substances.

12. Conditioning of Radioactive Waste consists of those operations that produce a Waste Package suitable for safe handling, transport, Storage and Disposal. Conditioning may

include the immobilisation of liquid Waste or dispersible Waste, the enclosure of the Waste in a container and the provision of an Overpack (as necessary).

13. Waste Packages produced by Conditioning should satisfy the respective acceptance criteria. Therefore, the Authority and organisations operating or planning to operate transport services and Storage and Disposal Facilities should be consulted in deciding which types of Pre-treatment, Treatment and Conditioning will be necessary.

14. Liquid Radioactive Waste is often converted into a solid form by solidifying it in a suitable matrix such as cement, bitumen or polymer. Solidification may also be achieved without a matrix material, for example by drying. The product is then enclosed in a container.

15. To the extent practicable the solidification process for liquid Radioactive Waste should produce a Waste form with the following characteristics and properties:

    a. Compatibility (physical and chemical) of the Waste, any matrix materials and the container;
    b. Homogeneity;
    c. Low voidage;
    d. Low permeability and leachability;
    e. Chemical, thermal, structural, mechanical and radiation stability for the required period of time;
    f. Resistance to chemical substances and organisms.

16. Solid Radioactive Waste should be considered on a case-by-case basis. The characteristics of the Waste form as listed above apply for many types of solid Radioactive Waste. Some of the characteristics (in particular homogeneity and low voidage) do not apply for certain types of solid Radioactive Waste.

17. It should be taken into account that certain metals such as aluminium, magnesium and zirconium could react with the alkaline water of a cement slurry or water diffused from a concrete matrix to produce hydrogen. Chelating agents, organic liquids or oil and salt content in liquid Waste may also be of concern in the Conditioning process.

18. The Waste and its container should be compatible. Depending on the Waste characteristics and the method of handling, transport and Storage, the container may also need to provide shielding for direct radiation. In selecting materials for the container and its outer surface finish, consideration should be given to the ease of decontamination. If a container is not initially designed to meet the relevant acceptance criteria for transport, Storage or Disposal, an additional container or an Overpack will be necessary to meet the acceptance criteria. Care should be taken to consider the compatibility of the Waste Package and the Overpack with respect to the Waste acceptance specifications.

19. If there may be a significant delay before an acceptable Disposal route becomes available, the container should provide integrity during the Pre-disposal Storage period and should be capable of allowing for:

    a. Retrieval at the end of the Storage period;
    b. Enclosure in an Overpack, if necessary;
    c. Transport to and handling at a Disposal Facility;
    d. Performance as required in the Disposal environment.

20. Other Design consideration for Treatment and Conditioning of Radioactive Waste:

    a. Radioactive Waste Treatment and Conditioning systems should be designed to ensure that Protection and Safety for plant operating personnel is optimised for both Operation and Maintenance activities
    b. Equipment or components for the Treatment and Conditioning of Radioactive Waste should be selected on the basis of performance requirements, ease of maintenance or replacement of components, reliability, and ease of Operation
    c. Process instrumentation and control should be provided for equipment that is located in high radiation zones to be remotely operated.
    d. Redundancy of Treatment equipment to provide reliable and flexible Processing capability

21. For Nuclear Power Plants, the US Nuclear Regulatory Commission (NRC) Regulatory Guide (RG) 1.143: Design Guidance for Radioactive Waste Management Systems, Structures, and Components installed in Light Water Cooled Nuclear Power Plants offers appropriate detailed guidance. Licensees may alternatively wish to demonstrate optimisation of the treatment and conditioning strategy through application of the bset available techniques (BAT) approach outlined in the guidance issued by the UK Environment Agency.

Storage of Radioactive Waste

Article (7)

1. Storage is an option that should be considered in any Waste management strategy. Proper Storage should be available at all stages in Waste processing for isolation and environmental protection; it should also facilitate retrieval for subsequent steps. Detailed guidance on the safe Storage of Radioactive Waste is provided in IAEA Safety Guide WS-G-6.1 Storage of Radioactive Waste. For Nuclear Power Plants, NUREG 0800 SRP 11.4 Appendix 11.4 A Design for Temporary Storage of Low Level Radioactive Waste provides detailed guidance.

2. Radioactive Waste may be stored to allow its radioactivity to decay to levels that permit the authorised Discharge, authorised use or removal of Regulatory Control. Storage may also be necessary for operational reasons; for example, to permit off-site transfer at specified time intervals.

3. Sufficient Storage capacity should be provided for Waste generated in normal operations with a reserve capacity for Waste generated in any incident or abnormal event. Extension of this capacity may be necessary in the event that the Waste cannot be transferred off the site because, for example, a Disposal Facility is not available.

4. Waste contaminated with radionuclides of very short half-life (up to about 100 days) could be collected and stored until it meets criteria established by the Authority for the Clearance of Regulatory Control or for authorised Discharge or use.

5. In Facilities in which significant volumes of liquid Waste are generated, collection tanks should be the preferred container for liquid Waste. The tanks should be constructed of chemically resistant material such as stainless steel, plastic, rubber lined carbon steel or fibreglass that can be demonstrated to be effective for the life of the Facility. Secondary containment should be provided around the tank to prevent the spread of contamination in the event of leakage. In addition tanks should have overflows routed to the floor drains or other suitable collection point. The tank Design should provide for complete drainage and cleaning.The provision of adequate shielding should also be considered.

6. Collection and Storage tanks should have appropriate equipment for stirring, venting and Waste transfer to prevent the sedimentation of sludges and the accumulation of hazardous gases in the tank. Provision should be made for sampling and for the reserve capacity necessary for unplanned events. The floor of the room or area where liquid Waste is stored or processed should be sealed against the penetration of liquids for ease of decontamination.

7. The integrity of Waste Packages in Storage should be ensured and the Storage Facility should be capable of maintaining the 'as received' integrity of the Waste Package until it is retrieved for further Treatment, Conditioning or Disposal. The Design of the Facility should permit radiation monitoring and Inspection, including visual or other examination of the Waste Packages to obtain an early indication of any physical deterioration or signs of leakage or the build-up of gas in the containers.

8. Radiation monitoring and visual Inspection should be performed whenever the Waste is handled or moved (placed into Storage, retrieved or transported off the site). This serves to protect workers handling the Waste, helps to prevent the accidental spread of contamination and provides an additional check of the record keeping system.

9. The Storage Facility should be adequately ventilated to exhaust any gas generated in normal Operation or under anticipated Accident conditions. Measures to prevent, detect

and control fires should be incorporated into the Design of Facilities for the Storage of combustible Waste.

10. Early leak detection systems should be considered in the Design where there is a potential for undetected leakages for extended periods such as in areas that are not routinely occupied. For Nuclear Power Plants, US NRC Reg Guide 4.21, Minimization of Contamination and Radioactive Waste Generation: Life-Cycle Planning.

Safety Assessment and the Safety Case

Article (8)

1. The Safety Case should be prepared by the Licensee early in the development of a Facility and be progressively developed and refined as the project proceeds. Such an approach ensures the quality of the technical programme and the associated decision making. For the Licensee, it provides a framework in which confidence in the technical feasibility and Safety of the Facility can be established at each stage of its development. This confidence has to be developed and enhanced by means of iterative Design studies and Safety studies as the project progresses. The step-by-step approach has to provide for the collection, analysis and interpretation of the relevant technical data, the development of plans for Design and Operation, and the development of the Safety Case for operational Safety.

2. The Safety Case for a Pre-disposal Radioactive Waste Management Facility must include a description of how all the Safety aspects of the site, the Design, Operation, shut-down and Decommissioning of the Facility, and the managerial controls satisfy the regulatory requirements. The Safety Case and its supporting Safety Assessment must demonstrate the level of protection provided and must provide assurance to the Authority that Safety requirements will be met. The Safety Case should identify uncertainties in the behaviour and performance of the Pre-disposal system, analyse the significance of the uncertainties, and identify approaches for the management of significant uncertainties.

3. The Design of the Facility, the arrangements for operational management and the systems and processes that are used need to be considered and justified in the Safety Case. This has to involve the identification of Waste arisings and the establishment of an optimal programme of Waste management to minimise the amount of Waste generated and to determine the Design basis and operational basis for the Treatment of effluents, the control of Discharges and Clearance procedures. The primary aim of the Safety Case is to ensure that the Safety objectives and criteria set by the Authority are met.

4. The Safety Case has to address operational Safety and all Safety aspects of the Facility and activities. The Safety Case has to include considerations for reducing hazards posed

to workers, members of the public and the environment during normal Operation and in possible Accident conditions.

5. The extent and detail of the Safety Case and the Safety Assessment have to be commensurate with the complexity of the operations and the magnitude of the hazards associated with the Facility and activities.

6. The Safety Case and its supporting Safety Assessment should be documented at a level of detail and to a quality sufficient to demonstrate safety, to support the decision at each stage and to allow for the independent review and approval of the Safety Case and Safety Assessment. The documentation must be clearly written and must include arguments justifying the approaches taken in the Safety Case on the basis of information that is traceable.

7. Justification has to involve explaining why particular choices were made and stating the arguments in favour of and against the decisions made, especially those decisions that relate to the main approaches taken in the Safety Case.

8. Traceability refers to the possibility of following the information that is provided in the documentation and that has been used in developing the Safety Case. For the purposes of both justification and traceability, a well-documented record is necessary of the decisions and assumptions that were made in the development and Operation of the Facility, and of the models and data used in the Safety Assessment to obtain the set of results. Good traceability is important for the purposes of technical and regulatory review and for building public confidence.

9. Clarity refers to good structure and presentation at an appropriate level of detail such as to allow an understanding of the arguments included in the Safety Case. This necessitates that the documents present the work in such a way that the interested parties for whom the documents are intended can gain a good understanding of the Safety arguments and their bases. Different styles and levels of documentation may be necessary, depending on the intended audience for the material.

Record-keeping

Article (9)

1. The Licensee should establish a procedure for maintaining adequate documentation and records in accordance with the Quality Assurance programme. The scope and detail of the records will depend on the hazard and/ or the complexity of the proposed operation and should be subject to approval by the Authority.

2. The requirements are for the records that relate to the Radioactive Waste Management Facility, the Waste itself and compliance with the acceptance criteria for Waste disposal to be retained for a period agreed with the Authority. These records should include:

   (a) The data needed for a national inventory of Waste;
   (b) The data needed for Waste characterisation;
   (c) The records from the control processes for Treatment, packaging and Conditioning;
   (d) The documents on the procurement of containers required to provide confinement for a certain period (e.g. in a repository);
   (e) The specifications for Waste Packages and audit records for individual containers and packages;
   (f) Trends in operating performance;
   (g) Non-compliances with the specifications for Waste Packages and the actions taken to rectify them;
   (h) The monitoring records;
   (i) The results of Safety Assessments;
   (j) The written operating procedures;
   (k) Any additional data as required by the regulatory body.

3. A Waste characterisation record should contain the following information pertaining to the Waste:

   (a) The source or origin;
   (b) The physical and chemical form;
   (c) The amount (volume and/ or mass);
   (d) The radiological characteristics (the activity concentration, the total activity, the radionuclides present and their relative proportions);
   (e) The classification in accordance with the national Waste classification system;
   (f) Any chemical, pathogenic or other hazards associated with the Waste and the concentrations of hazardous material;
   (g) Any special handling necessary owing to criticality concerns, the need for the removal of decay heat or significantly elevated radiation fields.

Annex A 1

Specific Guidance for the Pre-disposal Management of Disused Sealed Sources of Low Radioactivity (≤ 100MBq)

1. Disused sealed sources of low radioactivity present fewer management problems than high radioactivity sources because they have a low contact Dose rate and many are suitable for near-surface Disposal.

2. The Radioactive Material in low radioactivity sources is usually encased in plastic or metal. The source is designed to contain the radioactivity for the Design purpose and certified life of the source. To ensure the source is not damaged, low activity sealed sources should not be subjected to compaction, shredding or incineration.

3. Even though most sealed sources with radioactivity less than 100 MBq do not require additional security measures under FANR Regulation 23 for the Securirty of Radioactive Sources (FANR-REG-23), measures should be established to deter unauthorised access to stored disused sources and the presence of the sources verified at set intervals.

4. The preferred options for managing low activity disused sources are by return to the manufacturer or re-use. If return to the manufacturer or re-use are not viable options, then the sources should be managed as Radioactive Waste. In this case, it is often preferable to keep individual radioisotopes separate. Waste classification of the sealed sources should comply with the classification in Article 4 (5) of this Regulatory Guide.

PRE-TREATMENT

5. Low radioactivity sources should be segregated to facilitate Storage and Disposal. The degree of segregation depends on the number and types of sources. At a minimum, sources should be segregated into short-lived, medium-lived and long-lived sources using these criteria

    a. Short-lived material with a half-life less than six years (i.e. includes cobalt-60 with half-life 5.3 years);
    b. Medium-lived material with a half-life of more than six years but less than 40 years (i.e. includes caesium-137 with half-life 30.1 years and strontium-90 with half-life 28.8 years); and
    c. Long-lived material with a half-life of more than 40 years.

6. If a large number of sources are being managed, it may be advantageous to further segregate the sources based on the radionuclides present and the type of source.

7. Many disused short-lived sources can be managed by Storage to allow the Radioactive Material to decay to below the Clearance level, when they no longer need to be managed as Radioactive Waste. A period of 10 half-lives reduces the level of radioactivity of any source by a factor of 1000 but a longer period may be required for more intense sources.
8. If decay to Clearance levels is not viable, the source will need to be stored until a Disposal route is available. Most low activity (<100 MBq) disused sources are likely to meet the Waste acceptance criteria for near-surface Disposal Facilities.

SOURCE AND CONTAINER INTEGRITY

9. Sources should be checked for leakage of radioactive contents. Source leakage is usually assessed by performing wipe tests. The type of test undertaken is dependent upon the radionuclide and the activity of the source. Leak checking should be undertaken by competent personnel from an organisation that has been approved by the Authority. If the source is found to be leaking, the source should be overpacked in a container approved for Storage while the future course of action is assessed and approved.

10. Removal of a leaking source from any housing or shielding will require monitoring the removed material. Material found to be contaminated should be decontaminated or treated as Radioactive Waste.

11. For sources that are not leaking, consideration should be given to their potential re-use. If a source is reusable, it should be transferred to the new user or placed into Storage for future use. If the source cannot be re-used then the source should be returned to the manufacturer, if possible. Disused sources that are not reusable and cannot be returned to the manufacturer should be treated as Waste.

TREATMENT

12. It is usually preferable to remove the Radioactive Sources from gauges and instruments to minimise the volume of material to be managed as Radioactive Waste. This should be performed by a Qualified Expert.

13. In order to ease handling the source safely, consideration should be given to keeping the source in any housing and shielding if this is of relatively small volume.

14. Sources should initially be consolidated into containers that are marked with a radioactivity symbol and stored in a secure location. A label on the container should indicate the container number, the radionucide and activity contained, the maximum contact Dose rate and the reference date(s) for the activity and the Dose rate.

15. In order to facilitate transport to and from Storage locations, it is preferable to consolidate material in Type A containers for transport or in containers that fit into Type A containers - see FANR Regulation 13 for the Safe Transport of Radioactive Materials (FANR-REG-13).

CONDITIONING

16. The extent of Conditioning depends on the likely Disposal route. If there is uncertainty as to whether a group of sealed sources will be accepted for Disposal, the sources should not be irretrievably conditioned until Waste acceptance criteria are issued for an established repository unless there are clear Safety or security benefits.

17. Sources should be stored in containers made from stainless steel or other material suitable for the expected period of Storage. For small sources, the container could be stored in a concrete-lined drum to provide shielding. The container should be retrievable from the concrete-lined drum.

18. It is preferable not to backfill larger containers with grout or other matrix until it is clear what is required by the repository Waste acceptance criteria.

Annex A 2

Specific Guidance for Pre-disposal Management of Disused Sealed Sources of Higher Radioactivity (>100MBq)

1. Disused sealed sources of higher activity present management problems because of the high radioactivity content and the usually high radiation Dose rate when the sources are not shielded.

2. The radioactivity in some sealed sources can be in a dispersible powder form. The source is designed to be a robust item for the certified life of the source and the Design purpose of the source. To ensure the source is not damaged, sealed sources should not be subjected to compaction, shredding or incineration.

3. The radioactivity level in some sources is high enough to pose a significant risk to individuals, society and the environment. Security requirements for high radioactivity sealed sources are provided in FANR-REG-23.

4. Sources containing higher levels of radioactivity are usually treated as a special case when it comes to Storage and Disposal. Due to the higher radioactivity concentrations, scenarios involving human intrusion into the repository in the Safety Assessment for Disposal of sealed sources may be more limiting than for more dispersed Radioactive Waste. The Waste acceptance criteria for a Storage and a Disposal Facility are likely to have specific requirements for sealed sources. As far as possible, irreversible Treatments should be avoided in Processing higher activity sealed sources until clear Waste acceptance criteria for Disposal are developed.

PRE-TREATMENT

5. Pre-treatment includes collection of Waste, segregation of Waste and Waste decontamination. The purpose of Pre-treatment is to reduce the amount of Waste requiring further Processing and Disposal or to alter the packaging or Waste form to facilitate further Treatment.

6. Disused sealed sources should be collected and the records pertaining to each Waste item examined. Records should include details of the following:

    a. the source container identification number;
    b. the radionuclide(s) present;
    c. the activity of the source and date of measurement;
    d. identification of the purpose for which the material was used;
    e. the surface Dose rate and the date of measurement;
    f. the mass and volume of the package; and

g. the Person responsible for the prior management of the source.

If any of these details are not available then they should be determined before proceeding with further Waste Processing.

7. Source certification documentation should be reviewed and the originals stored in a secure location. The certification period on the source documentation should be checked and a renewal sought from the Authority before the certification period expires. Transport of sealed sources becomes more difficult if the special form (see FANR-REG-13) certification has lapsed.

8. Disused sealed sources that can be re-used or returned to the manufacturer should be dealt with at this stage, removing the need for their further management as Radioactive Waste. For re-use to be a viable option, the source certification should be current for the expected period of future use. Otherwise, return of disused sealed sources to their manufacturer is the preferred option. The manufacturer should have the capability to assess whether the source or contained radioactivity can be recycled, disassembled or transferred to a Radioactive Waste Management Facility and the personnel and equipment to disassemble and re-certify sources if appropriate.

9. If return to manufacturer or re-use are not options, then the sources need to be managed as Radioactive Waste. Waste classification of the sealed sources should comply with the classification in Article 4 (5) of this Regulatory Guide.

10. Sealed sources of higher activity should be segregated on the basis of half-life to facilitate management. A possible segregation would be based in the definition of short-lived, medium-lived and long-lived radionuclides:

    a. short-lived material with half-life less than 6 years (i.e. includes cobalt-60 with half-life 5.3 years);
    b. medium-lived material with half-life more than 6 years but less than 40 years (i.e. includes caesium-137 with half-life 30.1 years and strontium-90 with half-life 28.8 years); and
    c. long-lived material with half-life more than 40 years.

11. Many short-lived sources can be managed by Storage to allow decay. They can also potentially be disposed of to near-surface Disposal Facilities because their radioactivity decays to insignificant levels during the institutional control period of the Facility. After a period of 10 half-lives, i.e. 53 years for cobalt-60, the radioactivity reduces by a factor of 1000. For some high radioactivity cobalt-60 sources, 20 half-lives or more would be required for the level of radioactivity to reduce to insignificant levels.

12. Medium-lived sources can take many hundreds of years to decay to below Clearance levels. Hence their Disposal options depend on the particular radionuclide(s) in the

source. Only low level medium-lived sources are suitable for Disposal in a near surface repository. In general, it is preferable to dispose of medium-lived sources of higher activity in a geological Facility or deep borehole Facility.

13. Long-lived sources of higher activity need to be disposed of in a geological Facility or deep borehole Facility.

14. Disused sources can leak and potentially lead to the inhalation of, or contamination with, toxic materials. Consequently, general and industrial safety rules should be observed whenever disused sources are handled. Adequate ventilation and filtration systems should be in place to protect personnel and the environment.

SECURITY

15. FANR-REG-23 places special requirements on Radioactive Sources that pose a significant risk to individuals, society and the environment. It may apply to disused sources that appear as Waste and places specific requirements on the management of sources containing higher levels of radioactivity.

16. FANR-REG-23 defines categories for sources that could potentially cause severe health effects. When a source is declared as Waste, its category should be reassessed after taking into account any radioactive decay. Security arrangements implemented for the disused source should correspond to the category of the source.

SOURCE AND CONTAINER INTEGRITY

17. Sources should be checked for leakage of radioactive contents. Source leakage is usually assessed by performing wipe tests. The type of test undertaken is dependent upon the radionuclide and the activity of the source. Leak checking should be undertaken by competent personnel from an organisation that has been approved by the Authority. If the source is found to be leaking, the source should be overpacked in a container approved for Storage while the future course of action is assessed and approved.

18. Removal of a leaking source from any housing or shielding will require monitoring of the removed material. Material found to be contaminated should be decontaminated or treated as Radioactive Waste.

19. For sources that are not leaking, consideration should be given to their potential re-use. If a source is reusable, it should be transferred to the new user or placed into Storage for future use. If the source cannot be reused then the source should be returned to the manufacturer if possible. Disused sources that are not reusable and cannot be returned to the manufacturer should be treated as Waste.

20. The source management strategy should be risk-based and consistent with national and international guidance. The management strategy will take into account the radionuclide half-life, the source activity, the types of radiation emitted, the characteristics of the source Design and form of the radioactive substance.

21. Many higher activity sealed sources come with a primary container, which provides shielding and a locking system to secure the source. In the short term, the disused source should be kept in this primary container to provide shielding and security. The state of the primary container should be assessed as part of the source characterisation and a decision made whether to keep the source in the primary container or to design and construct a replacement container.

TREATMENT

22. The first stage of Treatment is volume reduction by removal of extraneous parts of the source housing and instrument components. The volume reduction should be performed only to the extent that maintains an adequate level of safety and security for the source being treated. A means of locking the source in its housing should be kept or new locking system provided. The extraneous material removed should be checked for contamination and managed accordingly, either by Storage or cleaning if contaminated, or by Disposal or reuse if not contaminated.

23. The next stage of volume reduction is removal of the sources from the original devices and, if appropriate, grouping them together with similar sources for Conditioning. This can allow the use of standard Storage containers and shielding, as well as optimising safety and security measures. Source removal requires dedicated Facilities and experienced personnel. Damaged and leaking sources will require extra precautions as well as specialised equipment providing both shielding and containment. Care should be taken not to weaken or damage the source.

24. Waste Packages for disused sources should confine the radioactivity in the source both under normal conditions and under Accident conditions. The Storage container should shield radiation to allow for handling, protect the source against mechanical and corrosion effects and prevent unauthorised access to the source.

25. A source holder or source containment device should be selected that is appropriate to the form and type of the source it is to contain. For example, some caesium sources are made of caesium chloride powder, which can corrode a stainless steel capsule from the inside in the long-term. Whilst low activity caesium-137 sources are now usually prepared in ceramic form, making the radionuclide less dispersible, the ceramic form is not suitable for high activity caesium-137 sources.

26. Wherever possible, a number of sources should be consolidated into one container to minimise the volume of Waste for Disposal. The number and activity of sources for

consolidation should be carefully considered to ensure the limits for transportation as an acceptable category are not exceeded. If possible, the total activity in a package should be kept within the limits for transport as a Type A package. Limits for the amount of radioactivity in a Type A container for different radionuclides are specified in FANR-REG-13.

CONDITIONING

27. The Conditioning process for disused sealed sources normally involves immobilising the Waste in a suitable matrix, containing the immobilised Waste in a suitable container and providing any additional packaging. The purpose of the Conditioning process is to produce a packaged Waste suitable for the selected Disposal option that meets requirements for Waste handling, Storage and transport.

28. Sealed sources of higher radioactivity should not be irreversibly conditioned until Waste acceptance criteria are available for a Disposal Facility. This usually means that the source should not be immobilised in a matrix until there is a Disposal Facility available to accept the Waste. However, safety considerations may warrant some immobilisation to provide adequate safety during Storage.

29. The Conditioning matrix should ensure low leachability of radionuclides from the Waste form. The matrix should also be compatible with both the Waste and the container. Sources can be encapsulated into welded or sealed steel capsules, and stainless steel drums to facilitate future management. Due to the toxicity of lead, the use of lead pots for containment should be kept to a minimum. Free space within containers should be kept to a minimum to reduce the possibility of collapsing voids and ensure structural stability should the Waste Packages themselves be relied upon for maintaining the structure of the Disposal Facility.

Annex B

Specific Guidance for Pre-disposal Management of Laboratory and Medical Waste

1. Radioactive laboratory and medical Waste is very diverse; it can contain a wide range of radionuclides with a wide range of activities in many different forms. This Annex considers unsealed source forms. A good understanding of the generation process usually provides knowledge of the radionuclides present and their concentrations. If knowledge of the generation process is poor, then the Waste should be characterised to provide the information required for Waste management.

2. Care should be taken to segregate Waste that may contain radioactivity from non-Radioactive Waste to minimise the amount of Radioactive Waste. Measurements should be undertaken on all Waste that may contain radioactivity so that Waste containing radionuclides below the limits given in Table I-1 of Schedule 1 of FANR-REG-24 Revision 1 can be treated as non-Radioactive Waste.

3. Waste that exceeds these limits should be assessed to determine if it can be discharged to the sewer or disposed of to a landfill.

4. For Waste containing short-lived radionuclides, it may be feasible to store the material to allow the radioactivity to decay to activities such that they fall below the limits or can be discharged to the sewer or disposed of to a landfill. Radioactive Waste held for decay should be kept in secure stores and each container should be clearly labelled with adequate information which may include numbering and a bar-code for cross-referencing with a Waste tracking database, a description of the radioactive contents, the activity when stored (with reference date), the anticipated date when it may be released from the store and the name of the person responsible for placing it in the store. In many instances in nuclear medicine, it may suffice to label containers of short-lived radionuclides with the date of Storage. An accurate inventory of all containers and their contents in the store at any time should be maintained.

5. Waste from different processes may contain different radionuclides and have different concentrations. The different Wastes should be segregated if segregation provides a significant benefit in optimising Waste management of the different Waste types. Segregation is most important if an organisation deals with both short-lived and long-lived radionuclides, or if it deals with both beta/gamma and alpha emitters. Waste containing or possibly containing alpha emitters should be segregated from Waste with no alpha emitters because Disposal limits for alpha emitters are much more restrictive than limits for beta/gamma emitters.

6. The low activity concentration of much laboratory and medical Waste means that most will be acceptable in a near-surface repository and generic Waste acceptance criteria are likely to provide a reasonable basis for treating and Conditioning laboratory Waste.

PRE-TREATMENT

7. The first Pre-treatment operation should be to collect the Radioactive Waste and segregate items on the basis of radiological, physical, chemical and pathogenic properties. Waste containing predominantly short-lived radionuclides should not be mixed with long-lived Waste.

8. Segregation is only worthwhile if the segregated Wastes will be treated differently as they move through the Waste management steps to Disposal or if Waste acceptance criteria for Disposal are likely to be different.

9. Knowledge of the processes generating the Waste may provide adequate knowledge of the radioactivity and radionuclides in the Waste. If this is not sufficient the Waste should be characterised. The initial characterisation could be based on knowledge of the process generating the Waste and the radionuclides involved in the process, combined with Dose rate and perhaps preliminary gamma spectroscopy. This initial characterisation could provide enough information to allow Disposal or Storage options to be determined.

10. Wastes of different types and radioactivity concentrations (or total radioactivity in the case of sources) may be segregated to facilitate Waste management according to the overall Waste management strategy and the available Facilities.

11. Considerations for segregation include:

- radioactivity concentration: higher radioactivity Waste separated from lower radioactivity Waste;
- radioactive decay: Waste containing long-lived alpha emitters should be separated from Waste with no alpha emitters;
- form: solid, gaseous and liquid Wastes are treated separately;
- combustible or non-combustible;
- compressible or non-compressible;
- metallic or non-metallic;
- fixed or non-fixed surface contamination;
- organic solvents;
- materials and objects that are pyrophoric, explosive, chemically reactive or otherwise hazardous;
- items containing free liquids or pressurised gases;
- Waste containing infectious agents or is regulated as medical Waste or is otherwise biohazardous; and
- animal carcasses and putrescibles materials.

12. A more definitive characterisation should be undertaken prior to any Treatment and/or Conditioning. This characterisation should be sufficiently comprehensive to provide adequate information for assessing Treatment steps and demonstrating compliance with the transport regulations (FANR-REG-13) and Disposal Waste acceptance criteria.

13. If all radionuclides in a Waste Package have half-lives less than about a year, consideration should be given to storing the Waste in a Storage Facility approved by the Authority until radioactivity has decayed to Clearance levels.

14. Other actions undertaken in pre-treatment could be to adjust the characteristics of the Waste to make it more amenable to further processing and to reduce or eliminate certain hazards posed by the Waste owing to its radiological, physical, chemical or pathogenic properties.

15. Larger items with limited contamination can sometimes be decontaminated to reduce the volume of Waste. Mechanical, chemical and electrochemical methods can be used to remove surface contamination from a large item. The decontamination process should be planned to ensure that the characteristics of the secondary Waste are compatible with the requirements for future management.

16. The Assessment as to whether to undertake decontamination should take into account the total amount of Waste that will be generated by the decontamination (including any plastic sheeting, cleaning equipment, and liquid Waste) and Doses to workers from the decontamination.

17. Some items can be disassembled to remove smaller radioactive components or contaminated items from a larger volume of non-Radioactive Material. Waste acceptance criteria for Disposal are likely to contain exclusions for polychlorinated biphenyls (PCBs), hazardous materials, infectious Waste, putrescible Waste and explosive materials; and limits on some combustible materials, lead and lead compounds, surfactants, flammable liquids, pressurised gases, chelating agents, organic liquids and free liquids. Estimates of these and similar hazardous and/ or toxic components should be determined from process knowledge or direct measurement, and the information documented and stored with the inventory so that it is available when the Waste is sent for Storage and Disposal.

18. In a hospital environment, linen including bedding, towels and personal clothing, which may be contaminated with Radioactive Materials should remain segregated from other linen and Waste until it has been monitored. If found to be contaminated, the article should be stored for decay until the amount of radioactivity is below the limits in table I-1 of Schedule 1 of FANR-REG-24 for the particular radionuclide. At that time the article can be laundered with other linen or disposed of as non-Radioactive Waste including return to the owner.

LIQUID WASTE

19. Liquid Radioactive Waste can be generated in laboratory or medical applications of Radioactive Materials. Limited quantities of aqueous liquids with low concentrations of Radioactive Material may be suitable for Discharge to the sewer.

20. Liquid Waste potentially containing radioactivity, which would cause the Discharge limit to be exceeded should be collected and stored for decay or other Treatment determined by the chemical, physical and biological hazards of the liquid including the radionuclide half life. Where aqueous liquid Radioactive Waste is regularly produced in a laboratory at a level where the effluent from laboratory sinks may conceivably cause the Discharge to the sewer to exceed the proposed Discharge authorisation level, sinks should be connected to a holding or delay tank system and these sinks should be restricted to uses involving Radioactive Materials. Where the volume of liquid Radioactive Waste is small, a labelled screw top container in the working area may be adequate.

21. Toilets used by in-patients being treated with radioactive iodine should be clearly marked and only used by those patients. Acknowledging that single rooms within hospitals are a valuable resource, such designated toilets when not in use by patients undergoing radioactive iodine therapy may be safely used for other patients if monitored and decontaminated correctly. If the effluent from these toilets may cause the Clearance limit of iodine-131 (10 Bq/g) from the premises to the sewer to be exceeded, the Authority may require that the toilets be connected to a holding tank system. The radioactivity and volume of the tank contents should be monitored continuously. Sufficient time should be allowed for decay of stored iodine-131 to below the Clearance level (10 Bq/g) before a tank is emptied.

22. Holding tanks for short-lived radionuclide Wastes are usually constructed in sets of two or more, so that one may be filling while the contents of a full one may be discharged after sampling.

23. Tanks for temporarily holding liquid Waste should:

- be leak-free;
- have visual indicators of the volume of the contents and warning devices to indicate when the tank is almost full;
- be enclosed in a secondary enclosure of sufficient volume to hold the contents if at any time there should be a loss of tank contents;
- have Facilities to monitor the amount of radioactivity or to allow easy withdrawal of representative samples;
- have a means to allow Inspection of build-up of deposits on the base or sides and to allow access for clearing (incorporation of mechanical agitators may reduce the incidence of deposits); and

- have sanitary controls and methane monitoring if the tank holds human or animal Wastes.

24. Liquid Waste should be characterised on the basis of process knowledge and preliminary measurement. Mixing liquid Waste streams should be limited to those streams that are radiologically similar and chemically compatible. It is usually preferable to treat a small amount of more concentrated liquid Waste rather than treat the large volume created when the more concentrated liquid is mixed into a larger volume of liquid with low or very low levels of radioactivity.

25. Aqueous liquid Waste streams should not be mixed with organic liquid Waste. Organic liquid Waste may be flammable, and its collection and Storage should incorporate provisions for adequate ventilation and fire protection.

26. The non-radiological characteristics of liquid Waste should be assessed to determine if there are other hazardous components in the Waste that limit the management options for the Waste.

TREATMENT

27. Treatment of laboratory Waste may include:

    - volume reduction by compaction of solid Waste by disassembly of bulky Waste components or equipment and by incineration of combustible Waste;
    - concentration and collection of radionuclides from liquid and gaseous Waste streams by evaporation or ion exchange for liquid Waste streams and filtration of gaseous Waste streams, and
    - change of form or composition by chemical processes such as precipitation flocculation and acid digestion as well as chemical and thermal oxidation.

28. In general, Treatment of Radioactive Waste requires approval from the Authority before any Treatment or Conditioning is undertaken. In some cases, this could already be included under an existing Licence; in others, specific approval will be required.

29. Compaction can be an effective method for reducing the volume of a compressible Waste. The characteristics of the material to be compacted and the desired volume reduction should be well defined and controlled. Issues to be taken into consideration in assessing the safety of compaction should include:

    - possible release of volatile radionuclides and other airborne radioactive contaminants as gases or dust;
    - possible release of contaminated liquid during compaction;
    - chemical reactivity of the material during and after compaction; and

- potential fire and explosion hazards due to pyrophoric or explosive materials or pressurised components.

30. Disassembly and other size reduction techniques may be used for Waste that is bulky or oversized in relation to the intended processing. Processes for size reduction can include sawing, hydraulic shearing, abrasive cutting, plasma arc cutting and cutting with high temperature flames. Preventing the spread of particulate contamination should be considered in the choice of method and in the operation of the equipment.

31. Combustible solid Waste and radioactive organic liquids may be incinerated, calcined or treated with other advanced oxidation techniques suitable for reducing the volume of Waste and producing a stable Waste form. After incineration, calcination or advanced oxidation, radionuclides from the Waste are distributed between the residue, the products from cleaning the exhaust gases and any stack Discharges. The distribution of radioactivity and other combustion products to each of these Waste streams should be assessed for all normal and abnormal conditions.

32. Any proposal for incineration, calcination or other advanced oxidation technique should be referred to the Authority for approval.

33. If the Radioactive Waste contains fissile material, the potential for criticality should be evaluated and eliminated by means of Design features and administrative controls.

34. Used filters from treating gases at Facilities using radioactivity are a solid Radioactive Waste. Care should be taken to ensure that Radioactive Materials trapped on filters are not dispersed during handling the filters or the subsequent Treatment of filters. Many filters will have only low levels of radioactivity and it may be worth assessing whether the level of radioactivity is below the Clearance levels given in FANR-REG-24. Revision 1 Filters containing radioactivity can usually be compacted to reduce the volume of Radioactive Waste to be managed.

35. For any Waste management process that potentially leads to airborne emissions, stack Discharges should be monitored to ensure that the concentrations and amounts of radionuclides discharged are within the limits specified by the regulatory body and are consistent with the parameters modelled in the safety Assessment.

36. Animal carcass Waste might be incinerated or treated with lime and an absorbent.

37. Specific absorbents are available for dealing with biological material, and the specific instructions should be followed.

TREATMENT OF LIQUIDS

38. Long-lived liquid Radioactive Waste requiring Storage should be converted to solid form as soon as practicable. Solid Waste is easier to store safely and a repository for Waste Disposal is likely to only accept solid Waste with limits on the amount of free liquid.

39. Treatment of organic liquid Waste, e.g. contaminated oil, depends on the organic liquid involved so relevant advice on Treatment options should be sought.

40. Methods for converting radioactive aqueous liquid Waste to a solid form include:
    - chemical precipitation, for example precipitating the radioactive component as hydroxide by raising the pH;
    - evaporation of liquid and management of the residue as solid Radioactive Waste;
    - incorporation into a matrix, e.g. added to a sand cement mortar, bitumen, polymer, ceramics or glass;
    - adsorption of radioactivity onto a solid, e.g. alum followed by centrifuging to separate the solids from the liquid;
    - the use of ion exchange resin; and
    - filtration, ultrafiltration and reverse osmosis.

41. Chelating agents, organic liquids or oil and salt content in liquid Waste may also be of concern in some Conditioning processes.

CONDITIONING

42. Conditioning laboratory Waste may include the conversion of the Waste to a solid Waste form, enclosure of the Waste in containers, and, if necessary, provision of an Overpack. Conditioning could also be encapsulation of contaminated items in an inert matrix, such as a cement or mortar.

43. Twenty litre, 60 litre and 205 litre steel drums are the preferred package sizes for laboratory Radioactive Waste. Galvanised or stainless steel drums have greater resistance to corrosion and may be preferred. A safety Assessment should be performed to ensure that the drum selected is suitable for the particular Waste type.

44. Other sized packages or type of package should be used if the safety Assessment demonstrates a significant advantage in doing so. A generator producing small amounts of Radioactive Waste might use smaller packages, but the smaller packages selected should be able to be packed into larger drums for ease of subsequent handling. If larger packages are indicated, future transport and handling requirements should be considered before deciding to use larger packages.

45. Consideration should be given to cutting larger items to fit into a 205 litre drum. The Dose rate on the outside of the package containing Radioactive Waste should be measured to ensure the package is suitable for the Storage Facility and the proposed mode of transport. Some Waste may need to be encapsulated in cement mortar to reduce the contact Dose rate on the outside of the package. Alternatively, additional temporary shielding and control procedures could be used to control access to areas with higher Dose rates.

46. Waste Packages produced by Conditioning should satisfy the criteria for transport, Storage and Disposal. To the extent practicable, Conditioning of Radioactive Waste should produce a Waste Package with the following characteristics and properties:
    - physical and chemical properties of the Waste are compatible with any matrix materials and the container;
    - low voidage;
    - low permeability and leachability;
    - chemical, thermal, structural, mechanical and radiation stability will be maintained for the required period of time;
    - resistant to chemical substances and organisms;
    - suitability for retrieval at the end of the Storage period;
    - suitability for transport to and handling at a Disposal Facility; and
    - meets Waste acceptance criteria of the Disposal Facility.

47. Some materials require specific Assessment before being encapsulated in concrete. Aluminium, magnesium and zirconium are known to react with the alkaline water of a cement slurry or water diffused from a concrete matrix to produce hydrogen.

48. The container may also need to provide radiation shielding. The selection of materials for the container and its outer surface finish should consider the ease of decontamination. An additional container or an Overpack may be needed to meet the acceptance criteria if the container does not meet the relevant criteria for transport, Storage or Disposal. Any such package should be designed to maintain integrity and containment of the radioactivity for an extended period of Storage if there could be a significant delay before an acceptable Disposal route becomes available.

Annex C

Specific Guidance for Management of Residues from Industrial Processing

1. Industrial process activities can produce large quantities of residues containing radioactivity; mainly low levels of naturally occurring Radioactive Materials (NORM) such as uranium, thorium and radium and their progeny. The radioactivity in bulk Waste is usually distributed uniformly through the Waste and the concentration of radioactivity is usually low.

2. Types of bulk Waste that can include radioactivity include:
   - scale from pipes and valves in the oil and gas industry;
   - Waste from mineral sands process activities;
   - Waste from titanium paint production; and
   - Waste from the phosphate industry.

3. FANR-REG-24 Revision 1 specifies the criteria for Clearance from Regulatory Control of Radioactive Material or practices. Usually the large bulk of residues from industrial process activities and Waste from remediation of contaminated sites means that the contained radioactivity will exceed the limit on total radioactivity quantity outlined in Table I-1 in Schedule I of FANR-REG-24 Revision 1. However, FANR-REG-24 Revision 1 also allows material to be granted Clearance if Exposure from the Radioactive Material in all reasonably foreseeable situations delivers an annual effective Dose to an individual member of the public in the order of 10 μSv or less, and that for low probability scenarios the Effective Dose does not exceed 1 mSv in a year.

4. It is also possible for the Authority to provide Clearance if it can be demonstrated that continued Regulatory Control of the material would yield no net benefit, in that no reasonable control measures would achieve a worthwhile return in terms of reduction in individual Doses or of health risks.

5. Using these Clearance provisions, the reuse and recycle of materials contaminated with NORM e.g. pipes, valves, etc. should be applied to keep the generation of Radioactive Waste to the minimum practicable, provided that Protection objectives are met.

PRE-TREATMENT

6. The main step in Pre-treatment is to characterise the Waste and determine the level of contained radioactivity, the radionuclides present, the presence of other toxic or hazardous substances, and the mobility of the radioactive species in the Waste. The process generating the Waste should be optimised to minimise the amount of Waste containing radioactivity generated and ensure that the radioactivity in the Waste is, as far as

practicable, insoluble and not mobile under Storage and Disposal conditions. If this cannot be achieved in the generating process, then the Waste should be treated to reduce the mobility of the radioactive species.

7. The appropriate Storage container depends on the amount of Waste generated. Medium amounts of Waste could be stored in 200 litre drums. If drums are used, they should be completely filled to minimise voidage and consideration be given to compressing the Waste to reduce total volume. Waste to be placed in drums should be dry to minimise the potential for corrosion of containers.

8. If the Waste occurs in large volumes, packing into drums is not likely to be appropriate. Rather, a Disposal route should be identified if possible, such as a dedicated near-surface Facility. A dedicated Storage Facility may be required to store the Waste until it can be disposed of. It may be advantageous to reduce the total volume of Waste and the number of shipments by separating out some of the non-radioactive components of the Waste. However, this would increase the activity concentration of the material which may or may not be an overall advantage. Also the separation procedure might be difficult or expensive and might be an additional source of exposure to the workers carrying out the separation.

TREATMENT

9. The residues from industrial process activities may need treatment to provide chemical stability to remove free liquid and to provide structural stability. The need for structural stability depends on the method of Disposal, which may require the Waste to have a specified compressive and/or shear strength. For Disposal, compressive strength is usually more important because potential for subsidence is a major concern for a near-surface Disposal Facility. Processes for treating residues from industrial process activities and Waste from site remediation should be assessed on a case by case basis for each different Waste type.

10. The Waste acceptance criteria for Disposal of bulk Waste are likely to include a requirement for dry solid Waste, minimal voidage and a compressive strength adequate to prevent subsidence.

CONDITIONING

11. The Conditioning requirements for bulk Waste need to be assessed case by case.

12. Some bulk Waste types may be conditioned by mixing with cement to form a structurally stable Waste form. Cement produces a highly alkaline environment, and the impact of the alkalinity on the bulk Waste should be assessed.

13. Most bulk Radioactive Wastes that occur as residues from industrial processes or from remediation of contaminated sites have a sufficiently low radionuclide concentration to be

accepted at a near-surface Disposal Facility or at a Facility that meets the criteria for a near-surface activity. If there are large volumes of Waste, consideration should be given to establishing such a Facility close to the source of the Waste to minimise transport.

14. In the oil and gas industry, consideration should be given to injecting scale contaminated with naturally occurring radioactivity down a spent or depleted well with recharge water where it can be demonstrated that there is no likelihood of the well ever being used again for extraction. This returns the radioactivity back to the geological depths from which it came and isolates the radioactivity from humans and the environment.