IAEA
SAFETY
STANDARDS
SERIES

Predisposal Management of Radioactive Waste, Including Decommissioning

SAFETY REQUIREMENTS

No. WS-R-2

INTERNATIONAL
ATOMIC ENERGY AGENCY
VIENNA

IAEA SAFETY RELATED PUBLICATIONS

IAEA SAFETY STANDARDS

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Information on the IAEA's safety standards programme (including editions in languages other than English) is available at the IAEA Internet site

www.iaea.org/ns/coordinet

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PREDISPOSAL MANAGEMENT OF RADIOACTIVE WASTE, INCLUDING DECOMMISSIONING

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The Agency's Statute was approved on 23 October 1956 by the Conference on the Statute of the IAEA held at United Nations Headquarters, New York; it entered into force on 29 July 1957. The Headquarters of the Agency are situated in Vienna. Its principal objective is "to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world".

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FOREWORD

by Mohamed ElBaradei
Director General

One of the statutory functions of the IAEA is to establish or adopt standards of safety for the protection of health, life and property in the development and application of nuclear energy for peaceful purposes, and to provide for the application of these standards to its own operations as well as to assisted operations and, at the request of the parties, to operations under any bilateral or multilateral arrangement, or, at the request of a State, to any of that State's activities in the field of nuclear energy.

The following advisory bodies oversee the development of safety standards: the Advisory Commission on Safety Standards (ACSS); the Nuclear Safety Standards Advisory Committee (NUSSAC); the Radiation Safety Standards Advisory Committee (RASSAC); the Transport Safety Standards Advisory Committee (TRANSSAC); and the Waste Safety Standards Advisory Committee (WASSAC). Member States are widely represented on these committees.

In order to ensure the broadest international consensus, safety standards are also submitted to all Member States for comment before approval by the IAEA Board of Governors (for Safety Fundamentals and Safety Requirements) or, on behalf of the Director General, by the Publications Committee (for Safety Guides).

The IAEA's safety standards are not legally binding on Member States but may be adopted by them, at their own discretion, for use in national regulations in respect of their own activities. The standards are binding on the IAEA in relation to its own operations and on States in relation to operations assisted by the IAEA. Any State wishing to enter into an agreement with the IAEA for its assistance in connection with the siting, design, construction, commissioning, operation or decommissioning of a nuclear facility or any other activities will be required to follow those parts of the safety standards that pertain to the activities to be covered by the agreement. However, it should be recalled that the final decisions and legal responsibilities in any licensing procedures rest with the States.

Although the safety standards establish an essential basis for safety, the incorporation of more detailed requirements, in accordance with national practice, may also be necessary. Moreover, there will generally be special aspects that need to be assessed by experts on a case by case basis.

The physical protection of fissile and radioactive materials and of nuclear power plants as a whole is mentioned where appropriate but is not treated in detail;

obligations of States in this respect should be addressed on the basis of the relevant instruments and publications developed under the auspices of the IAEA. Non-radiological aspects of industrial safety and environmental protection are also not explicitly considered; it is recognized that States should fulfil their international undertakings and obligations in relation to these.

The requirements and recommendations set forth in the IAEA safety standards might not be fully satisfied by some facilities built to earlier standards. Decisions on the way in which the safety standards are applied to such facilities will be taken by individual States.

The attention of States is drawn to the fact that the safety standards of the IAEA, while not legally binding, are developed with the aim of ensuring that the peaceful uses of nuclear energy and of radioactive materials are undertaken in a manner that enables States to meet their obligations under generally accepted principles of international law and rules such as those relating to environmental protection. According to one such general principle, the territory of a State must not be used in such a way as to cause damage in another State. States thus have an obligation of diligence and standard of care.

Civil nuclear activities conducted within the jurisdiction of States are, as any other activities, subject to obligations to which States may subscribe under international conventions, in addition to generally accepted principles of international law. States are expected to adopt within their national legal systems such legislation (including regulations) and other standards and measures as may be necessary to fulfil all of their international obligations effectively.

EDITORIAL NOTE

An appendix, when included, is considered to form an integral part of the standard and to have the same status as the main text. Annexes, footnotes and bibliographies, if included, are used to provide additional information or practical examples that might be helpful to the user.

The safety standards use the form 'shall' in making statements about requirements, responsibilities and obligations. Use of the form 'should' denotes recommendations of a desired option.

CONTENTS

1. INTRODUCTION

BACKGROUND

1.1. Waste containing or contaminated with radionuclides arises from a number of activities involving the use of radioactive materials, such as the operation and decommissioning of nuclear facilities and the application of radionuclides in industry, medicine and research. Radioactive waste is also generated in the cleanup of sites affected by radioactive residues from various operations or from accidents, and can arise in the processing of raw materials containing naturally occurring radionuclides. The nature of this waste is likely to be such that its safe management must take into account radiation safety considerations. In addition to the waste that must be managed and eventually disposed of, some of the materials arising during the aforementioned activities are of value and may be reused or recycled.

1.2. Predisposal management of radioactive waste, as the term is used in this Safety Requirements publication, comprises all waste management steps prior to disposal. These include the processing of operational and decommissioning waste as well as that of waste from cleanup activities. The decommissioning of a nuclear facility at the end of its useful lifetime is included in this definition of predisposal waste management. In the sense that decommissioning is the management of nuclear facilities for which no further use is foreseen, it is considered to be a part of radioactive waste management.

1.3. The general principles of managing radioactive waste in a safe manner have been set out in a Safety Fundamentals publication [1]. The present publication is concerned with the application of these principles to the predisposal area of radioactive waste management. A brief description of the general approach and the technical steps in predisposal management of radioactive waste is given in the following paragraphs.

1.4. In the design of facilities and the planning of activities that have the potential to generate radioactive waste, measures are put in place to avoid or reduce, to the extent practicable, its generation. Waste and other residual materials are appropriately collected or segregated after collection, as necessary. They may be released from regulatory control if they do not require further consideration from the viewpoint of radiation safety. This includes the controlled discharge of effluents produced during predisposal operations. As far as reasonably practicable, the reuse and recycling of materials are applied as means of minimizing waste generation. The remaining waste is processed in accordance with the national strategy for radioactive waste management for storage or disposal.

1.5. The principal approaches to the management of radioactive waste are commonly termed 'delay and decay', 'concentrate and contain' and 'dilute and disperse'. 'Delay and decay' involves holding the waste in storage until the desired reduction in activity has occurred through radioactive decay of the radionuclides contained in the waste. 'Concentrate and contain' means reduction of volume and confinement of the radionuclide contents by means of a conditioning process to prevent dispersion in the environment. 'Dilute and disperse' means discharging waste to the environment in such a way that environmental conditions and processes ensure that the concentrations of the radionuclides are reduced to such levels that the radiological impact of the released material is acceptable. In establishing policies in this area, consideration has to be given to the radiological impacts of the different management options. From a radiological protection perspective, a balance has to be struck between the present exposures resulting from the dispersal of radionuclides in the environment and potential future exposures which could result as a consequence of radioactive waste disposal [2].

1.6. The first two approaches ('delay and decay', 'concentrate and contain') require that radioactive waste be held in storage for varying lengths of time or placed in a disposal facility with a view to preventing its release to the environment. Radioactive waste must therefore be processed, as necessary, in such a way that it can be safely placed and held in a storage or disposal facility.

1.7. The third approach ('dilute and disperse') is a legitimate practice in the management of radioactive waste and has to be carried out within authorized limits established by the regulatory body [1].

Processing and storage of radioactive waste

1.8. Waste processing includes pretreatment, treatment and conditioning of radioactive waste and is intended to produce a waste form compatible with the selected or likely disposal option. Storage may take place between and within the basic steps of radioactive waste management [1]. The conditioned waste must be in a form suitable for handling, transport, storage and disposal.

1.9. It may be that not all processing steps are necessary. The type of processing necessary depends on the particular waste, its form and characteristics, and the overall strategy for waste management. Where appropriate, waste or material resulting from processing can be reused or recycled, or released from regulatory control.

1.10. Waste is prepared for disposal by means of the aforementioned processing steps. However, in many instances disposal facilities are not available and storage may be necessary for extended periods of time.

1.11. In order to select the appropriate type of pretreatment, treatment and conditioning for the radioactive waste when no disposal facility has been established, assumptions have to be made about the likely disposal option. Consideration has then to be given to the potential conflict between the need to contain and store the waste in a passive, safe condition and the desirability of retaining flexibility in waste form so as to avoid prejudicing the choice of eventual disposal options. In striking a balance between closing an option and retaining flexibility, it is necessary to ensure that conflicting requirements that might compromise safety are avoided [1].

Decommissioning

1.12. The term 'decommissioning' refers to administrative and technical actions taken to allow the removal of some or all of the regulatory controls from a nuclear facility (except for a repository, for which the term 'closed' and not 'decommissioned' is used). These actions involve decontamination, dismantling and removal of radioactive materials, waste, components and structures. They are carried out to achieve a progressive and systematic reduction in radiological hazards and are undertaken on the basis of preplanning and assessment, in order to ensure safety during decommissioning operations.

1.13. A facility may be considered decommissioned when an approved end state has been reached. Subject to national legal and regulatory requirements, this may encompass situations such as:

— incorporation into a new or existing facility; and
— partial or full dismantlement with or without restrictions on further use.

1.14. Decommissioning is facilitated if planning and preparatory work are undertaken at the design phase of the nuclear facility and are continued throughout the entire lifetime of the facility.

OBJECTIVE

1.15. The objective of this Safety Requirements publication is to establish, on the basis of the principles laid down in Ref. [1], the basic requirements that must be satisfied in predisposal management of radioactive waste from operations, decommissioning and cleanup, and the requirements governing the decommissioning of nuclear facilities.

SCOPE

1.16. This Safety Requirements publication applies to the predisposal management of radioactive waste arising from the operation and decommissioning of nuclear facilities, the application of radionuclides in industry, medicine and research, the processing of raw materials that contain naturally occurring radionuclides and the cleanup of contaminated sites. Safety requirements specific to the discharge of radionuclides to the environment, to near surface disposal, to geological disposal and to transport are established in other publications.

1.17. This publication deals with the safety requirements relevant to all activities in predisposal management of radioactive waste, including decommissioning, that bring radioactive waste into a state suitable for storage or disposal in designated facilities. Although it does not specifically address non-radiological hazards, these have to be considered by national authorities both in their own right and in as much as they affect radiological consequences.

1.18. This publication places emphasis on complex situations, which are typical in the predisposal management of radioactive waste from the nuclear fuel cycle. For less complex situations, not all requirements specified here may be necessary or appropriate. The regulatory body shall decide which requirements do not have to be taken into account in particular situations.

1.19. With respect to decommissioning, this publication deals primarily with the period after termination of normal operations. However, most provisions also apply to decommissioning after an abnormal event that has resulted in serious damage or contamination at a facility.

STRUCTURE

1.20. This Safety Requirements publication deals in its initial part with the protection of human health and the environment (Section 2) and the responsibilities of the parties involved in predisposal management of radioactive waste, including decommissioning (Section 3). It then outlines the interdependence among the steps in predisposal management of radioactive waste (Section 4) and the elements of predisposal management of radioactive waste (Section 5), in particular waste processing and storage and also waste generation and acceptance criteria for radioactive waste disposal. It addresses relevant aspects of the decommissioning of nuclear facilities (Section 6), in particular, planning for decommissioning, decommissioning operations and completion of decommissioning. Finally, it specifies the safety

and environmental impact assessments and the quality assurance in predisposal management of radioactive waste and decommissioning activities that shall be applied in order to achieve safety (Section 7).

2. PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

2.1. Processes and operations applied in predisposal management of radioactive waste contribute to ensuring that radioactive waste is dealt with in a manner that protects human health and the environment, now and in the future, without imposing undue burdens on future generations [1].

2.2. In considering options in the predisposal management of radioactive waste, due consideration shall be given to the protection of workers and the public and to the protection of the environment. Protection shall also be provided beyond national borders [1]. Such considerations shall include radiological and non-radiological hazards, including conventional health and safety aspects, and the potential impact and burden on future generations from extended periods of storage of radioactive waste or delayed decommissioning of nuclear facilities.

2.3. The predisposal management of radioactive waste is part of the entire 'practice' giving rise to the waste in the context of the recommendations of the International Commission on Radiological Protection (ICRP) [3] and the IAEA [4]. Radiation protection considerations should therefore be governed by the concepts of justification of a practice, optimization of protection and limitation of doses to individuals [1]. The generation and management of radioactive waste does not need to be justified separately since it should have been taken into account in the justification of the entire practice [1].

2.4. National radiation protection requirements shall be established with due regard for the International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources (BSS) [4]. In particular, the radiation protection of any persons who are exposed as a result of activities in predisposal management of radioactive waste shall be optimized, with due regard to dose constraints, and with the exposures of individuals kept within specified dose limits.

2.5. The dose limits for normal exposure of workers and members of the public shall be applied as prescribed in national regulations. Internationally endorsed values for these limits are contained in Schedule II of the BSS [4].

2.6. In addition to provision for protection against the normal exposures referred to in the preceding paragraphs, provision shall be made for protection against potential exposures. A potential exposure is one that is not expected to be delivered with certainty but that may result from an incident or an accident. Requirements for protection against potential exposures are established in the BSS [4]. They include managerial and technical measures to prevent the occurrence of incidents or accidents and provisions for mitigating their consequences should they occur.

2.7. Requirements for environmental protection associated with predisposal management of radioactive waste shall be established by the national regulatory body, taking into consideration all potential environmental impacts that can reasonably be expected.

2.8. A 'safety culture' shall be fostered and maintained in both the operating organization and the regulatory body in order to encourage a questioning and learning attitude to protection and safety and to discourage complacency. Such a culture is particularly important for decommissioning activities in which new radiological and non-radiological hazards may arise, for example, owing to the removal of safety systems and barriers. This includes the regular audit and review of performance.

3. RESPONSIBILITIES ASSOCIATED WITH PREDISPOSAL MANAGEMENT OF RADIOACTIVE WASTE, INCLUDING DECOMMISSIONING

GENERAL

3.1. As stated in Principle 6 of Ref. [1], clear allocation of responsibilities is essential to ensure safety in radioactive waste management. Internationally endorsed requirements on the allocation of such responsibilities, in particular those of the regulatory body, are provided in Ref. [5] and will not be repeated here. However, selected responsibilities of the various parties involved that are specific to predisposal management of radioactive waste, including decommissioning (see Sections 4, 5 and 6), are outlined below.

3.2. It is possible that predisposal management of radioactive waste will involve the transfer of the radioactive waste from one operator to another, or that the radioactive waste may even be processed in another country. Similarly, decommissioning may be carried out by an operator different from the operator responsible for facility operation.

Furthermore, decommissioning may be deferred or carried out in a series of discrete operations over time (phased decommissioning). The established legal framework shall contain provisions to ensure that there is clear and unequivocal allocation of responsibility for safety during the entire process of predisposal management of radioactive waste. This continuity of responsibility for safety shall be ensured through regulatory control, e.g. by a licence or a sequence of licences according to the national legal framework.

3.3. In the event of the transfer of radioactive waste beyond national boundaries, account shall be taken of the relevant requirements of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management [6]. These relate, inter alia, to the need for prior notification and consent of the State of destination, the need for adequate technical and administrative capacity in the State of destination and provisions for movements through transit States.

3.4. In the context of decommissioning, the post-operational phase of a nuclear facility, starting with the final shutdown and extending over the entire decommissioning process, shall be regulated, e.g. by a licence, a sequence of licences or other regulatory control, according to the national legal framework.

REGULATORY BODY

3.5. To facilitate effective and safe predisposal management of radioactive waste, the regulatory body shall ensure that an appropriate waste classification scheme is established in accordance with national programmes and requirements and international recommendations [7].

3.6. To protect human health and the environment, the regulatory body shall establish requirements and criteria pertaining to the safety of facilities, processes and operations for predisposal management of radioactive waste. These shall include requirements related to handling, transport and storage as well as known or likely requirements associated with the acceptance of waste packages for disposal.

3.7. The regulatory body shall establish safety criteria for the decommissioning of nuclear facilities (see Section 6), including conditions on the end points of decommissioning.

3.8. The regulatory body shall establish limits and conditions for the removal of controls from materials containing radionuclides. It shall provide guidance for the authorized use of materials and for the authorized discharge of liquids and gases

containing radionuclides [1, 4, 8] (see Glossary). The regulatory body shall also consider establishing criteria for the clearance of materials [4, 9, 10]. Such limits, conditions and criteria shall ensure the protection of human health and the environment and shall take account of international recommendations [3, 4].

3.9. The regulatory body shall ensure that relevant documents and records are prepared, kept for an agreed time and maintained to a specified quality. It shall ensure that appropriate parties are responsible for this work.

OPERATORS

3.10. Generators of radioactive waste, including organizations carrying out decommissioning activities, and the operators of radioactive waste management facilities are considered to be engaged in predisposal management of radioactive waste. In the context of this Safety Requirements publication, they are hereinafter referred to as 'operator(s)'.

3.11. The operator shall be responsible for all aspects of safety of the facility for predisposal management of radioactive waste during its lifetime and of the decommissioning activity until its completion (Principle 9, Ref. [1]).

3.12. In order to provide an adequate level of safety, the operator shall perform safety and environmental impact assessments; shall prepare and implement appropriate safety procedures; shall apply good engineering practice; shall ensure that staff are trained, qualified and competent; shall establish and implement a quality assurance programme; and shall keep records as required by the regulatory body.

3.13. Unless otherwise required by the regulatory body, the operator shall establish and maintain decommissioning plans which are commensurate with the type and status of the facility. The initial decommissioning plan shall be established in the design phase of the facility.

3.14. The operator shall establish and maintain emergency planning commensurate with the hazards associated with the predisposal management of radioactive waste and the decommissioning activities, and shall report incidents significant to safety to the regulatory body in a timely manner.

3.15. The operator shall identify an acceptable destination for the radioactive waste and shall ensure that radioactive waste is transported safely and in accordance with transport requirements [11] (see also para. 3.3).

3.16. The operator may delegate any work associated with the aforementioned responsibilities to other organizations but shall retain overall responsibility and control.

3.17. A mechanism for providing adequate financial resources shall be established to cover the costs of radioactive waste management and, in particular, the cost of decommissioning. It shall be put in place before operation and shall be updated, as necessary. Consideration shall also be given to providing the necessary financial resources in the event of premature shutdown of the facility.

3.18. At the completion of decommissioning, and before the operator can be relieved of further responsibility for the facility or site in accordance with the national legal framework, the operator shall provide to the regulatory body such information as may be required.

4. INTERDEPENDENCE

4.1. Interdependences among all steps in the generation and management of radioactive waste shall be appropriately taken into account (Principle 8, Ref. [1]). Owing to the existing interdependences among the various steps in radioactive waste management, all activities from the generation of the waste to its disposal shall be seen as parts of a larger entity, and each component shall be selected so as to be compatible with the others.

4.2. The operator shall examine and the regulatory body shall review the different processing options in order to identify the appropriate options and to avoid conflicting requirements that might compromise safety. It is not consistent with an integrated approach to optimize one step in predisposal management of radioactive waste, including decommissioning, in such a way that it imposes significant constraints on following steps or forecloses viable options.

5. ELEMENTS OF PREDISPOSAL MANAGEMENT OF RADIOACTIVE WASTE

5.1. Various factors should be balanced when deciding between options in the predisposal management of radioactive waste. These factors include the nature and

amount of radioactive waste, occupational and public exposures, environmental effects, human health and safety, and economic considerations.

5.2. In predisposal management of radioactive waste, decisions often have to be made at a time when a disposal facility is not available and the waste acceptance requirements for the repository are still unknown. A similar situation would arise if radioactive waste were to be stored for safety reasons or other reasons over extended periods of time. In both cases it should still be considered whether, from the point of view of safety, the radioactive waste should be stored in a raw, treated or conditioned form. In making such decisions, the anticipated needs of any future steps in radioactive waste management, in particular disposal, shall, as far as possible, be considered and applied in processing the waste.

5.3. When it is proposed to store radioactive waste or to defer decommissioning for an extended period of time, consideration shall be given to the principle that "radioactive waste shall be managed in such a way that will not impose undue burdens on future generations" (Principle 5 [1]).

5.4. At various stages in the process of predisposal management of radioactive waste, the radioactive waste shall be characterized in terms of its physical, chemical, radiological and biological properties. Such characterization shall serve to provide information relevant to process control and assurance that the waste or waste package will meet the acceptance criteria for storage, transport and disposal. Provisions shall be made for identifying, assessing and dealing with waste or waste packages that do not meet process specifications or disposal criteria. Appropriate collection or segregation may expedite the achievements of such goals.

WASTE GENERATION

5.5. To keep radioactive waste arisings to the minimum practicable (Principle 7, [1]), careful planning shall be applied to the design, construction, operation and decommissioning of nuclear facilities.

5.6. Measures to control radioactive waste generation, in terms of both volume and activity content, shall be considered throughout the lifetime of a nuclear facility, beginning with the design phase; through the selection of materials for the construction of the facility; by the control of materials and the selection of the processes, equipment and procedures throughout the operation of the facility; and through the incorporation, into the design, of features to facilitate future decommissioning.

5.7. Reuse and recycling of materials shall be applied to the extent possible to keep the generation of radioactive waste to the minimum practicable and to contribute to the sustainable use of natural resources.

5.8. Authorized discharge, authorized use and clearance of materials from regulatory control, if necessary after an appropriate treatment and/or a sufficiently long storage period, can be effective in reducing the volume and amount of radioactive material that requires further processing. However, it shall be ensured that these management options, if implemented, are in compliance with the conditions and criteria established by the national regulatory body. In the application of such options, the regulatory body shall ensure that due account is given to non-radiological hazards.

WASTE PROCESSING

5.9. Materials with characteristics that make them unsuitable for authorized discharge, authorized use or clearance from regulatory control and for which no further use is foreseen shall be processed as radioactive waste. Processing of waste may yield waste or material that is suitable for authorized discharge, authorized use or clearance from regulatory control.

5.10. The main purpose of processing radioactive waste is to produce a waste, packaged or unpackaged, that fulfils the acceptance requirements for disposal. The requirements for handling, transport and storage of waste packages shall also be fulfilled.

5.11. Waste shall be processed in such a way that the safety of the operations is appropriately ensured under normal conditions, that measures are taken to prevent the occurrence of incidents or accidents, and that provisions are made to mitigate the consequences should accidents occur. The processing shall be consistent with the type of waste, possible needs for storage, the disposal option, and requirements resulting from safety and environmental impact assessments.

5.12 Various methods may be applied for processing the different types of radioactive waste. Consideration shall be given to identifying suitable options and to assessing the appropriateness of their application. It shall be decided within the overall approach to radioactive waste management to what extent waste has to be processed, with account taken of the quantities, activities and physical and/or chemical nature of the radioactive waste to be treated, the technologies available, the storage capacity, and the availability of a disposal facility.

5.13. Radioactive waste shall be processed in such a way that the resulting waste, packaged or unpackaged, can be safely stored and retrieved from the storage facility for disposal. Considerations relating to safe storage shall include possible reactions within the waste form and between the waste and the waste container, and the compatibility of the waste package with the storage environment. The radioactive waste shall be processed and the container shall be selected to ensure sufficient stability in all respects. They shall also be compatible with the disposal option.

Pretreatment

5.14. Pretreatment may include operations such as waste collection, segregation, chemical adjustment and decontamination. Carrying out such operations requires an appropriate characterization of the waste which serves to enable the appropriate allocation of treatment and conditioning processes. One result of pretreatment of radioactive waste is to reduce the amount of radioactive waste that would be subject to additional processing and disposal. A further result of pretreatment is to adjust the characteristics of the remaining radioactive waste that might require treatment, conditioning and disposal to make it more amenable to additional processing and disposal.

5.15. All waste considered radioactive shall be collected. Decisions with respect to additional pretreatment (segregation, decontamination and chemical adjustment) shall be based upon appropriate consideration of the characteristics of the waste and of the requirements imposed by subsequent steps in the national programme of radioactive waste management (treatment, conditioning, transport, storage and disposal).

Treatment

5.16. Treatment of radioactive waste includes, when necessary, removal of radionuclides, reduction of volume and change of composition. Important goals of radioactive waste treatment are to enhance safety, in the short term by making immediate improvements in the characteristics of the waste, and in the long term as one of a series of steps contributing to the safe predisposal management of radioactive waste.

5.17. In making decisions with respect to the treatment of radioactive waste, account shall be taken of the plan for predisposal waste management and the interdependences between the basic steps in radioactive waste management. Safety shall be the overriding consideration.

Conditioning

5.18. Conditioning of radioactive waste includes operations such as immobilization and packaging. The purpose of conditioning is to produce a packaged solid waste form compatible with the selected disposal option and which also meets the requirements for transport and storage.

5.19. In selecting the conditioning process, the operator shall consider whether safety would benefit from the use of a matrix material and shall ensure compatibility of the radioactive waste with the selected materials and processes.

5.20. Waste packages shall be designed and produced such that radionuclides are confined under both normal conditions and the accident conditions assumed to occur in handling, storage, transport and disposal.

STORAGE OF RADIOACTIVE WASTE

5.21. Within the context of predisposal management of radioactive waste, storage refers to the placement of radioactive waste in a nuclear facility where appropriate isolation and monitoring are provided. In radioactive waste management, storage may take place between and within the basic radioactive waste management steps [1]. Storage may be used to facilitate the next step in radioactive waste management, to act as a buffer within and between radioactive waste management steps, or in awaiting the decay of radionuclides until authorized discharge, authorized use or clearance can be allowed.

5.22. Radioactive waste may be stored in solid, liquid or gaseous form or as raw, pretreated, treated or conditioned waste. The intention of storage is that the waste will be retrieved for authorized discharge, authorized use or clearance or for processing and/or disposal at a later time. The criteria for acceptance of waste packages in a storage facility shall therefore take account of the known or likely requirements for subsequent radioactive waste disposal. Safety requirements for the protection of human health and the environment shall be met by appropriate design, construction, operation and maintenance of the respective facilities, including provision for the eventual retrieval of the waste.

5.23. The radioactive waste storage facility shall be designed on the basis of the assumed conditions for its normal operation and assumed incidents or accidents. It shall be designed and constructed for the likely period of storage, preferably with passive safety features, with the potential for degradation taken into account. Provisions shall be made for regular monitoring, inspection and maintenance of the

waste and the storage facility to ensure continued integrity. The adequacy of the storage capacity should be periodically reviewed, with account taken of the predicted waste arising and the expected life of the storage facility.

5.24. For physically mobile forms of waste, eventual problems with the integrity of the containment can be mitigated if appropriate redundant storage capacity is available.

5.25. For liquid waste, agitation, for example, through stirring or pulsing, shall be provided, where necessary, to avoid precipitation of solids dispersed in the liquid.

5.26. Gas generation by radiolysis or chemical reaction may be associated with the storage of radioactive waste. The concentration of gases in air shall be kept below hazardous levels to avoid, for example, explosive gas/air mixtures.

5.27. The storage facility shall be designed in such a way that the waste can be retrieved whenever required.

5.28. If necessitated by the nature of the radioactive waste, dissipation of heat from the waste shall be ensured and criticality shall be prevented.

5.29. If radioactive waste containing short lived radionuclides is intended for eventual authorized discharge, authorized use or clearance, it shall be ensured that it is stored for a sufficiently long period of time for the radionuclides to decay below defined activity levels.

5.30. If, after storage, the radioactive waste does not meet the acceptance criteria for disposal, the operator shall conduct the necessary waste processing.

ACCEPTANCE CRITERIA FOR RADIOACTIVE WASTE DISPOSAL

5.31. Radioactive waste destined for disposal shall be processed to meet the acceptance criteria for disposal established with the approval of the regulatory body [7]. These criteria define the radiological, mechanical, physical, chemical and biological properties of the waste and of any package.

5.32. Packages containing radioactive waste intended for transport shall comply with limits established in the IAEA Transport Regulations, for example, on radionuclide inventories, external dose rates and surface contamination [11]. Criteria to meet handling and emplacement requirements at the disposal facility and to facilitate the identification of waste packages shall also be taken into account.

6. DECOMMISSIONING

DECOMMISSIONING PLAN

6.1. Decommissioning of nuclear facilities comprises (a) preparation and approval of a decommissioning plan; (b) the actual decommissioning operations; and (c) the management of waste resulting from the decommissioning activities. With respect to the predisposal management of waste arising from decommissioning, the earlier sections, especially Section 5, are applicable.

6.2. A decommissioning plan shall be developed for each nuclear facility, unless otherwise required by the regulatory body, to show that decommissioning can be accomplished safely. Account shall be taken of the eventual need to decommission a facility at the time it is being planned and constructed. For example, in the selection of construction materials, a number of factors have to be balanced with decommissioning in mind. Properly chosen materials can reduce the formation of activation products during operation and help to minimize the radiation exposures of the workforce engaged in decommissioning.

6.3. The decommissioning plan shall be reviewed regularly and shall be updated as required to reflect, in particular, changes in the facility or regulatory requirements, advances in technology and, finally, the needs of the decommissioning operation. If an abnormal event occurs, a new decommissioning plan or modification of the existing decommissioning plan may be necessary.

6.4. During the implementation of the decommissioning plan, revisions or amendments may need to be made to the plan in the light of operational experience gained, new or revised safety requirements, or technological developments.

DECOMMISSIONING OPERATION

6.5. When it has been decided to shut down a nuclear facility, the operator shall submit an application for permission to decommission the facility for approval by the regulatory body, together with the proposed final decommissioning plan. If it is intended to defer decommissioning, it shall be demonstrated in the final decommissioning plan that such an option is safe. Furthermore, a line of reasoning shall be provided to show that no undue burdens are imposed on future generations.

6.6. If final shutdown occurs before a decommissioning plan is prepared, decommissioning of the facility shall not be started until a satisfactory decommissioning plan has been approved by the regulatory body, unless otherwise decided by the regulatory body (see para. 6.2).

6.7. If the shutdown of a facility is sudden, as, for example, in the event of a severe accident, the facility shall be brought to a safe state before decommissioning is started in accordance with an approved decommissioning plan.

6.8. Decommissioning activities may generate large volumes of waste over short time periods, and the waste may vary greatly in type and activity and may include large objects. The operator shall ensure that appropriate means are available to manage the waste safely.

6.9. Dismantling and decontamination techniques shall be chosen which minimize waste arisings and airborne contamination.

6.10. Decommissioning activities such as decontamination, cutting and handling of large equipment and the progressive dismantling or removal of some existing safety systems have the potential for creating new hazards. The safety impacts of the decommissioning activities shall be assessed and managed so that these hazards are mitigated.

COMPLETION OF DECOMMISSIONING

6.11. Before a site may be released for unrestricted use, a survey shall be performed to demonstrate that the end point conditions, as established by the regulatory body, have been met.

6.12. If a site cannot be released for unrestricted use, appropriate control shall be maintained to ensure protection of human health and the environment.

6.13. A final decommissioning report, including any necessary final confirmation survey, shall be prepared and retained with other records, as appropriate.

7. SAFETY OF FACILITIES

GENERAL

7.1. In compliance with Principle 9 on the safety of facilities [1], the safety of operations involving radioactive waste and the decommissioning of nuclear facilities shall be ensured by means of safety assessment and quality assurance. Safety and environmental impact assessments before commissioning shall be performed to demonstrate that the facilities and operation will be adequately safe. A quality assurance programme shall be conducted to provide the necessary confidence throughout all stages of design, construction and operation that all relevant requirements and criteria are met.

SAFETY AND ENVIRONMENTAL IMPACT ASSESSMENTS

7.2. Facilities and activities for predisposal management of radioactive waste, including decommissioning activities, shall be subject to safety and environmental impact assessments in order to demonstrate that they are adequately safe and, more specifically, that they will be in compliance with safety requirements established by the regulatory body.

7.3. These safety and environmental impact assessments shall address the facility's structures, systems and components, the waste to be processed and all associated operational work activities, and shall encompass both normal operation and anticipated incidents and accidents. In the latter case, the safety and environmental impact assessments shall demonstrate that appropriate measures have been taken to prevent incidents or accidents and that consequences would be mitigated should an incident or accident occur.

7.4. The extent and detail of the safety and environmental impact assessments shall be commensurate with the complexity and the hazard associated with the facility or operation.

7.5. The results of the safety and environmental impact assessments shall be used to bring appropriate safety related improvements to predisposal waste management activities and decommissioning activities in order to reduce the likelihood of incidents or accidents and to mitigate their consequences should they occur.

QUALITY ASSURANCE

7.6. A comprehensive quality assurance programme [12] shall be applied to all stages and elements of predisposal radioactive waste management having a bearing on safety. It may include the siting, design, construction, operation and maintenance of radioactive waste management facilities. It also applies to the decommissioning of nuclear facilities and includes the maintenance and archiving of related documents and records, and all associated work activities and operations. Features important to safe operation, and therefore requiring consideration in the quality assurance programme, shall be identified on the basis of the results of the safety and environmental impact assessments.

7.7. The predisposal quality assurance programme shall be applied to the processing of the waste to ensure that all waste acceptance requirements are fulfilled. This will provide an assurance of adequate quality and will ensure compliance with the relevant standards and criteria.

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GLOSSARY

cleanup. Any measures that may be carried out to reduce the radiation exposure from existing contamination through actions applied to the contamination itself (the source) or to the exposure pathways to humans.

clearance. Removal of radioactive materials or radioactive objects within authorized practices from any further control by the regulatory body. (Removal from control in this context refers to control applied for radiation protection purposes.)

commissioning. The process during which systems and components of facilities and activities, having been constructed, are made operational and verified to be in accordance with design and to have met the required performance criteria.

conditioning. Those operations that produce a waste package suitable for handling, transport, storage and/or disposal. Conditioning may include the conversion of the waste to a solid waste form, enclosure of the waste in containers and, if necessary, providing an overpack. (See also immobilization and packaging.)

container, waste. The vessel into which the waste form is placed for handling, transport, storage and/or eventual disposal; also the outer barrier protecting the waste from external intrusions. The waste container is a component of the waste package. For example, molten HLW glass would be poured into a specially designed container (canister) where it would cool and solidify.

decommissioning. Administrative and technical actions taken to allow the removal of some or all of the regulatory controls from a facility (except for a repository, which is ‘closed’ and not ‘decommissioned’).

discharge, authorized. Planned and controlled release of (usually gaseous or liquid) radioactive material into the environment in accordance with an authorization.

disposal. Emplacement of waste in an appropriate facility without the intention of retrieval. (Some countries use the term ‘disposal’ to include discharges of effluents to the environment.)

immobilization. Conversion of waste into a waste form by solidification, embedding or encapsulation. Immobilization reduces the potential for migration or dispersion of radionuclides during handling, transport, storage and/or disposal.

packaging. Preparation of radioactive waste for safe handling, transport, storage and/or disposal by means of enclosing it in a suitable container.

practice. Any human activity that introduces additional sources of exposure or exposure pathways or extends exposure to additional people or modifies the network of exposure pathways from existing sources, so as to increase the exposure or the likelihood of exposure of people or the number of people exposed. Radioactive waste is generated as a result of practices that involve some beneficial effect, such as the generation of electricity by nuclear means or the diagnostic application of radioisotopes. The management of these wastes is therefore only one part of the overall practice.

predisposal. Any waste management steps carried out prior to disposal, such as pretreatment, treatment, conditioning, storage and transport activities. Decommissioning is considered to be a part of predisposal management of radioactive waste.

pretreatment. Any or all the operations prior to waste treatment, such as collection, segregation, chemical adjustment and decontamination.

repository. A nuclear facility where waste is emplaced for disposal.

storage. The holding of radioactive waste in a facility that provides for its containment with the intent of retrieval.

treatment. Operations intended to benefit safety and/or economy by changing the characteristics of the waste. Three basic treatment objectives are:

— volume reduction
— removal of radionuclides from the waste, and
— change of composition.

Treatment may result in an appropriate waste form.

use, authorized. Use of radioactive materials or radioactive objects from an authorized practice in accordance with an authorization.

waste. Material for which no further use is foreseen.

waste form. The waste in its physical and chemical form after treatment and/or conditioning (resulting in a solid product) prior to packaging. The waste form is a component of the waste package.

waste package. The product of conditioning that includes the waste form and any container(s) and internal barriers (for example, absorbing materials and liner), as prepared in accordance with requirements for handling, transport, storage and/or disposal.

waste processing. Any operation that changes the characteristics of waste, including pretreatment, treatment and conditioning.

waste, radioactive. For legal and regulatory purposes, waste that contains, or is contaminated with, radionuclides at concentrations or activities greater than clearance levels as established by the regulatory body.

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