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Management of radioactive waste from nuclear facilities —

Part 1: General principles, objectives and practical approaches

Gestion des déchets radioactifs des installations nucléaires — Partie 1: Principes généraux, objectifs et approches pratiques

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 85, *Nuclear energy, nuclear technologies, and radiological protection*, Subcommittee SC 5, *Nuclear installations, processes and technologies*.

A list of all parts in the ISO 24389 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The IAEA outlines a framework for the long-term management of radioactive waste, including waste from operational activities and waste from decommissioning activities. This framework sets out the objectives, criteria and requirements for the protection of human health and the environment that apply to the siting, design, construction, commissioning, operation and shutdown of facilities for the predisposal management of radioactive waste, and the requirements that should be met to ensure the safety of such facilities and activities.

However, additional practical guidance is required to assist development of processes for the safe, secure, efficient, effective management of radioactive waste. This document has been developed to provide the guidance needed for consistent implementation of the framework provided by the IAEA, while also enabling member states to develop processes that meet their own applicable requirements. This includes considerations with regards to

— safety,

— waste prevention,

— security (non-proliferation),

— lifecycle management (e.g., waste minimization, repurposing or reuse, effectiveness, efficiency, acceptance criteria for disposal), and

— applicable requirements for waste certification.

The guidance provided in this document considers the need to demonstrate fitness for purpose of applied solutions and the requirement for continuous improvement. Long-term disposal requirements are not addressed in this document.

This series of standards provides guidance in the following areas:

ISO 24389-1: General principles, objectives and practical approaches

ISO 24389-2: Pre-disposal

ISO 24389-3: Disposal

ISO 24389-4: Governance

ISO 24389-5: Data quality

ISO 24389-6: Documentation

ISO 24389-7: Supporting systems

Management of radioactive waste from nuclear facilities —

Part 1:
General principles, objectives and practical approaches

1 Scope

This document is the first of a series of seven documents which outlines the general principles to manage the various type of radioactive waste, and provides guidance for the practical implementation of those principles.

The purpose of this document is to address the following:

a) principles, objectives and practical approaches for radioactive waste management;

b) outline of the structure of series from ISO 24389-1 through ISO 24389-7.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 12749-3, *Nuclear energy, nuclear technologies, and radiological protection — Vocabulary — Part 3: Nuclear fuel cycle*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12749-3 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1 General terms

NOTE General terms are arranged alphabetically (English).

3.1.1
decommissioning
administrative and technical actions taken to allow the removal of some or all of the regulatory controls from a *nuclear facility* (3.1.3)

[SOURCE: IAEA. IAEA Safety Glossary, 2018 edition[1], modified — “nuclear” added.]

3.1.2
non-proliferation
prevention of the spread of nuclear weapons, fissionable material, and weapons-applicable nuclear technology and information

3.1.3
nuclear facility
facility (including associated buildings and equipment) in which nuclear material is produced, processed, used, handled, stored or disposed of

[SOURCE: IAEA. IAEA Safety Glossary, 2018 edition[1]]

3.1.4
proportional
corresponding in size or amount to something else

EXAMPLE Punishment should be proportional to the offense.

3.1.5
resource(s)
stock or supply of money, materials, staff, and other assets that can be drawn upon to achieve a specific function or outcome

3.1.6
safeguards
preventing the diversion of civil nuclear materials to non-peaceful applications

3.1.7
stakeholder
person, group or organization that has interests in, or can affect, be affected by, or perceive itself to be affected by, any aspect of a project, programme or portfolio

[SOURCE: ISO 21500:2021,[2] 3.18, modified — "the project" changed to "a project".]

3.2 Terms related to waste management

NOTE These terms are arranged conceptually based on the order of concepts as presented in this document.

3.2.1
radioactive waste
material for which no further use is foreseen that contains, or is contaminated with, radionuclides

Note 1 to entry: For legal and regulatory purposes, waste is considered to be radioactive if the concentrations or activities are greater than clearance levels as established by the regulatory body.

[SOURCE: ISO 12749-3:2015, 3.7.1]

3.2.2
radioactive waste management
all administrative and operational activities involved in the handling, pretreatment, treatment, conditioning, transport, storage and disposal of *radioactive waste* (3.2.1)

[SOURCE: IAEA. IAEA Safety Glossary, 2018 edition[1]]

3.2.3
waste handling
physical manipulation (sorting, moving, etc.) of waste or waste packages.

[SOURCE: IAEA Radioactive Waste Management Glossary]

Note 1 to entry: INTERNATIONAL ATOMIC ENERGY AGENCY, Radioactive Waste Management Glossary, Non-serial Publications, IAEA, Vienna (2003)

3.2.4
predisposal
predisposal management
any waste management steps carried out prior to disposal, such as pretreatment, treatment, conditioning, storage and transport activities

Note 1 to entry: Predisposal is not a form of disposal: predisposal is used as a contraction of 'pre-disposal management of radioactive waste'.

[SOURCE: IAEA. IAEA Safety Glossary, 2018 edition[1]]

3.2.5
recycle
convert [*radioactive waste* (3.2.1)] into reusable material

3.2.6
reduce
make smaller or less in amount

3.2.7
waste processing
any operation that changes the characteristics of waste, including pretreatment, treatment and conditioning

[SOURCE: IAEA. IAEA Safety Glossary, 2018 edition[1]]

3.2.8
waste pre-treatment
any or all of the operations prior to waste treatment, such as collection, *segregation* (3.2.10), *chemical adjustment* (3.2.11) and *decontamination* (3.2.12)

[SOURCE: IAEA. IAEA Safety Glossary, 2018 edition[1]]

3.2.9
waste retrieval
process of recovering *radioactive waste* (3.2.1) from a storage facility for *waste disposal* (3.2.20)

3.2.10
segregation
activity where types of *radioactive waste* (3.2.1) or material (radioactive or exempt) are separated or are kept separate on the basis of radiological, chemical and/or physical properties, to facilitate *waste handling* (3.2.3) and/or *waste processing* (3.2.7)

[SOURCE: IAEA. IAEA Safety Glossary, 2018 edition[1]]

3.2.11
chemical adjustment
change to the state, condition or properties of a material using chemical means

3.2.12
decontamination
complete or partial removal of contamination by a deliberate physical, chemical or biological process

[SOURCE: IAEA. IAEA Safety Glossary, 2018 edition[1]]

3.2.13
volume reduction
step or steps taken to *reduce* (3.2.6) the volume of *radioactive waste* (3.2.1)

3.2.14
waste treatment
operations intended to benefit safety and/or economy by changing the characteristics of *radioactive waste* (3.2.1)

[SOURCE: IAEA. IAEA Safety Glossary, 2018 edition[1]]

3.2.15
waste conditioning
operations that produce a waste package suitable for *waste handling* (3.2.3), transport, *waste storage* (3.2.19) and/or *waste disposal* (3.2.20)

Note 1 to entry: Conditioning can include the conversion of the waste to a solid waste form, enclosure of the waste in containers and, if necessary, provision of an overpack.

[SOURCE: IAEA. IAEA Safety Glossary, 2018 edition[1]]

3.2.16
waste immobilization
conversion of waste into a waste form by solidification, embedding or encapsulation

Note 1 to entry: The intent is to reduce the potential for migration or dispersion of radionuclides during *waste handling* (3.2.3), transport, *waste storage* (3.2.19) and/or *waste disposal* (3.2.20).

[SOURCE: IAEA. IAEA Safety Glossary, 2018 edition[1]]

3.2.17
waste packaging
preparation of *radioactive waste* (3.2.1) for safe *waste handling* (3.2.3), transport, *waste storage* (3.2.19) and/or *waste disposal* (3.2.20) by means of enclosing it in a suitable container

[SOURCE: IAEA. IAEA Safety Glossary, 2018 edition[1]]

3.2.18
waste overpack
secondary (or additional) outer container for one or more waste packages, used for *waste handling* (3.2.3), transport, *waste storage* (3.2.19) and/or *waste disposal* (3.2.20)

[SOURCE: IAEA. IAEA Safety Glossary, 2018 edition[1]]

3.2.19
waste storage
holding of *radioactive waste* (3.2.1) in a facility that provides for its containment, with the intention of *waste retrieval* (3.2.9)

[SOURCE: IAEA. IAEA Safety Glossary, 2018 edition[1]]

Note 1 to entry: The main distinguishing factor between waste storage and *waste disposal* (3.2.20) is the intention of *waste retrieval* (3.2.9), which applies to storage but not to disposal.

3.2.20
waste disposal
emplacement of waste in an appropriate facility without the intention of *waste retrieval* (3.2.9)

[SOURCE: IAEA. IAEA Safety Glossary, 2018 edition[1]]

3.2.21
repository
nuclear facility (3.1.3) where *radioactive waste* (3.2.1) is emplaced for disposal

[SOURCE: ISO 12749-3:2015, 3.7.9.1]

4 Principles, objectives and practical approaches

IAEA has published a document on radioactive waste management objectives[3] which describes principles and objectives for radioactive waste management. These are summarized below and are explained within the context of this document.

4.1 Principles and objectives

4.1.1 Principle 1: Benefits

Objective: Minimization of generation and optimization of the management of radioactive waste.

The main benefit of nuclear energy is in the electricity produced from it and related improvements in quality of life, while the management of radioactive waste generated in the process of electricity production is one of its costs. The overall benefit of nuclear energy is therefore enhanced if generation of radioactive waste is minimized by proper measures applied at source and during its processing and the waste is optimally (i.e. safely and cost effectively) managed.

4.1.2 Principle 2: Transparency

Objective: Establishment of methods and approaches for building trust among persons involved and affected by the management of radioactive waste.

Issues surrounding radioactive waste management have raised concerns among the wider stakeholder community (including the public). Experience has shown that progress towards the goal of optimally and safely managing and ultimately disposing of radioactive waste can only be made if the concerned members of the stakeholder community believe and respect the persons and organizations responsible for waste management.

To build this trust, the stakeholders, many of whom have no formal role in the decision-making process, have to see that their views are being taken seriously and that they can influence events. Openness, consistency and transparency are key elements in building trust.

4.1.3 Principle 3: Protection of people and the environment

Objective: Implementation of radioactive waste management methods that ensure the protection of people and the environment.

Radioactive waste is potentially hazardous, and it shall be managed in ways that ensure the protection of the public and the environment for as long as it remains hazardous. Policies for safely managing radioactive waste have been agreed and published.

Technologies have been developed for handling, processing, storing and disposing of radioactive waste so as to ensure that people and the environment are protected. Well established infrastructures are in place in many states to provide for the implementation of safe management procedures for radioactive waste.

Appropriate management techniques have been developed for most types of radioactive waste; however, there are some waste streams where additional attention is needed to ensure that the public and environment are properly protected. In these situations, technology enhancement and development are necessary to ensure adequate protection of the public and the environment.

4.1.4 Principle 4: Security

Objective: Implementation of physical protection systems relevant to radioactive waste.

Some types of radioactive material, although considered to be waste, can still pose a security threat. Consequently, consideration shall be given to adequate and appropriate control, accounting and security measures to prevent this happening.

The application of nuclear security principles to the early stages of design and implementation of new radioactive waste management facilities has the potential to increase security, decrease operational impact, lower operating costs and allow for greater integration with safety and safeguards systems.

Security and safety measures shall be designed and implemented in an integrated manner.

4.1.5 Principle 5: Non-proliferation

Objective: Incorporation of nuclear safeguards requirements in the design and operation of radioactive waste management facilities.

Spent nuclear fuel could be processed and the recovered nuclear material used in the production of nuclear weapons. International safeguards obligations and requirements for reporting and verification of nuclear material have been defined and apply to all locations at which such material is used or stored and to disposal facilities containing these spent fuel and waste.

The safeguards system, and the implemented safeguards measures, shall provide assurance that nuclear material has not been diverted. Safeguards requirements shall be considered in the design and operation of all radioactive waste and spent fuel management facilities containing nuclear material. These requirements shall consider State specific, facility specific and material specific factors, such that they can be implemented without compromising the safety of the facilities and minimizing impacts on operations.

4.1.6 Principle 6: Long-term commitment

Objective: Development of solutions that provide for the long-term management of radioactive waste.

Radioactive waste management is a long-term challenge that has to be properly addressed. This has been recognized for many years and technical solutions have been developed for the waste processing and waste disposal for all types of waste. However, in many States, there have been delays in the development of repositories for the disposal of radioactive waste and, as a result, the waste is stored for longer periods of time. It is important that clear strategies are developed to facilitate disposal at the appropriate time.

To ensure the long-term control of radioactive waste management systems, responsibilities should be clearly allocated, and provisions should be made for the availability of the necessary technical and human resources and for sufficient financial resources over appropriate timescales. Adaptive solutions might also be required to meet the potential needs of future generations.

4.1.7 Principle 7: Resource efficiency

Objective: Promotion of radioactive waste management methods and schemes that save resources and utilize them efficiently.

Many opportunities exist to reduce the use of resources in managing radioactive waste, such as the segregation, recycling and reuse of materials that might otherwise be declared as waste during the operation and decommissioning of nuclear facilities, either directly, if not contaminated, or after decontamination or storage for decay to reach acceptable levels. Similarly, innovative techniques are needed for the decontamination of buildings and clean-up of contaminated land to permit their release for unrestricted use and development. Natural resources are also saved by generating less waste through optimization of processes, resulting in the reduction of the size of storage and disposal facilities.

Spent nuclear fuel that has been declared as radioactive waste, can be either subjected to appropriate conditioning prior to disposal, or it can be considered as a resource for further use (reprocessing/partitioning or feed for other reactors).

Decisions on resource saving measures should be made as part of a comprehensive radioactive waste and spent fuel management policy and strategy, taking into consideration many factors, not least the

financial and feasibility aspects as well as social license. This can sometimes limit the potential for resource saving.

4.1.8 Principle 8: Continual improvement

Objective: Steady improvement of methods and technologies in radioactive waste management.

Many methods and technologies employed in radioactive waste management are generally well established, but it is important that efforts continue to be made to improve upon them. The aim should be to develop methods and technologies that improve the efficiency of long-term radioactive waste management and that reduce costs while ensuring the required levels of safety and security.

This document provides guidance for establishing practical approaches to implementing these objectives. Table 1 compares the objectives with the practical approaches described in this document and indicates where an approach can be used to achieve a given objective.

4.2 Practical approaches

4.2.1 Ensure optimum design of waste management lifecycle

Design and implementation of the system that is developed for the management of radioactive waste throughout its lifecycle (generation through to disposal) should be optimised to ensure efficiency.

The lifecycle for the management of radioactive waste and the stages in it shall be established ideally during the design of any facility. For existing facilities this shall be established as soon as is practicable and agreed with all relevant stakeholders.

The licensees or facility operators shall be responsible for agreement of process; definition of stages in the process; definition of the processes, technologies, etc. which will be employed at each stage in the process; lifecycle management of records associated with the waste management process, etc.

4.2.2 Ensure process is safe, secure, and effective

Design and implementation of the processes for the lifecycle management of radioactive waste, from generation through to disposal, shall be safe, secure and effective.

The analysis of the safety, security and effectiveness of a process shall be performed as soon as the process has been selected and consolidated; to guarantee the safety, security and effectiveness the process analysis shall be performed from the material and waste generation to the generation of final waste packages or material release.

The licensees or facility operators shall be responsible for the safety and security evaluations which have to be reliable, traceable, etc. The safety of a process shall be substantiated in deliverables with a grade of details sufficient to let the competent authority perform an independent analysis and authorize the related activities.

4.2.3 Conformity with applicable acceptance criteria

Both interim and final radioactive waste products shall be in conformity with appropriate acceptance criteria; e.g. with downstream processes and facilities, including current and future processes and facilities.

The analysis of compatibility with the acceptance criteria of each stage of the overall process shall be performed during the safety, security and effectiveness analysis of the process.

Responsibilities of the licensees or facility operators:

— Data acquired during processes and stages shall be of quality and reliably managed and tracked for many years through generations.

— responsible for ensuring that newly developed technologies for pre-treatment, conditioning and other process implementation should be evaluated and certified on a case-by-case basis. For technologies without the established acceptance criteria, the evaluation should include the consideration of appropriate acceptance criteria equivalent to the legacy established practices.

Licensees or facility operators shall establish a strong and reliable management system to be applied from the early stage of the lifecycle of waste management to ensure the fulfilment of waste acceptance criteria.

In order to ensure that the waste meet the acceptance criteria for processing, storage, transport and disposal (for all the stages of predisposal activities) licensees or facility operators shall define, in accordance with requirements established or approved by the regulatory body, a characterization approach at various steps of the overall process.

The defined acceptance criteria for each step of the overall process shall conform to criteria that are consistent with the safety case and safety analysis of the related facility.

4.2.4 Minimization of radioactive waste (e.g. reduce, reuse, recycle)

Design of facilities, processes, plant and equipment should seek to minimise the amount of radioactive waste that is produced, to be managed, and ultimately disposed of.

Measures to control the generation of radioactive waste, in terms of both volume and radioactivity content, have to be considered before the construction of a nuclear facility, on the basis of a robust analysis of the waste handling and of the processes inside the facility, selecting the correct material for the facility realization, defining correct procedures for both operations and decommissioning.

The licensees or facility operators shall be responsible for identifying non-radioactive waste versus radioactive waste, and for the latter, they shall be responsible for volume reduction and cost minimization by utilizing appropriate treatments, conditionings, reuse, and recycling (see Figure 1).

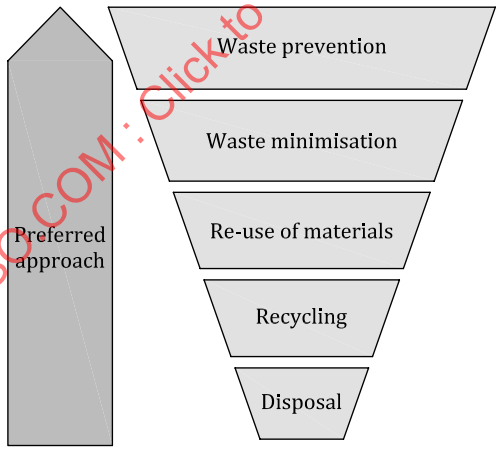

Figure 1 — Waste hierarchy[4]

4.2.5 Minimize environmental impacts for present and future generations

Radioactive waste management solutions should be developed which reduce the impact on the environment and do not create an environmental legacy that future generations will inherit.

Licensees or facility operators shall substantiate the minimization of the environmental impact by means of a specific environmental impact assessment.

The environmental impact assessment prepared by licensees or facility operators shall conform to the requirements for the development of radioactive waste management facilities and activities established

by the regulatory body. The environmental assessment shall be periodically updated by licensees and facility operators and reviewed by regulatory body.

4.2.6 Protection from facility accident and emergencies

Facilities, processes plant and equipment associated with any aspects of the lifecycle management of radioactive waste from generation to disposal should be designed and implemented with full consideration of the potential for accidents and emergencies, and the consequences associated with those, so as to reduce the risk to a level that is acceptable to all stakeholders.

4.2.7 Waste management solutions should be proportional to risk/hazard

Waste management solutions should be developed with a full understanding of the risks that are posed by the waste and the facilities, plant and equipment that are developed to manage it. These should be reduced to a level that is demonstrably acceptable.

4.2.8 Ensure the above principles are part of routine business

The principles of waste management should be embedded as business as usual (BAU) within the organisations that design nuclear facilities, produce the radioactive waste, and those that develop solutions for its management.

Licensees or facility operators shall be responsible to use advances in technology, the experiences and lessons learned from implementing waste management process and stages, and seek to gather and embody established good and/or best practice for waste management (See Clause 4)

4.2.9 Provide best value (cost effectiveness)

Radioactive waste management solutions should be developed which can be demonstrated as providing the best return on investment, to all stakeholders.

4.2.10 Suitable characterization

Characterization of radioactive waste is a key enabler to developing optimised waste management solutions.

Table 1 — Objectives and practical approaches[a]

		Objective							
		1	2	3	4	5	6	7	8
		Minimization of generation and optimization of the management of radioactive waste	Establish methods and approaches for building trust	Implement radioactive waste management methods that ensure the protection of people and the environment	Implement physical protection systems	Incorporate nuclear safeguards requirements into design and operation	Provide for long term management of radioactive waste	Promote methods that save resources and utilize them efficiently	Steady improvement of methods and technologies
Practical Approach	4.2.1-Ensure optimum design of waste management lifecycle	X		X		X	X	X	
	4.2.2-Ensure process is safe, secure, and effective		X	X	X	X			
	4.2.3-Compliant with applicable acceptance criteria (e.g., regulatory)			X			X		

[a] "X" indicates where an approach is suitable to fulfill a given objective

Table 1 *(continued)*

		Objective							
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
		Minimization of generation and optimization of the management of radioactive waste	Establish methods and approaches for building trust	Implement radioactive waste management methods that ensure the protection of people and the environment	Implement physical protection systems	Incorporate nuclear safeguards requirements into design and operation	Provide for long term management of radioactive waste	Promote methods that save resources and utilize them efficiently	Steady improvement of methods and technologies
Practical Approach	4.2.4-Minimization of waste (e.g. reduce, reuse, recycle)	X	X				X		
	4.2.5-Minimize environmental impacts for present and future generations			X					
	4.2.6-Protection from facility accident and emergencies			X			X		

[a] "X" indicates where an approach is suitable to fulfill a given objective