

IAEA SAFETY STANDARDS SERIES

Predisposal Management of High Level Radioactive Waste

SAFETY GUIDE

No. WS-G-2.6



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PREDISPOSAL MANAGEMENT OF HIGH LEVEL RADIOACTIVE WASTE

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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 bodies oversee the development of safety standards: the Commission on Safety Standards (CSS); the Nuclear Safety Standards Committee (NUSSC); the Radiation Safety Standards Committee (RASSC); the Transport Safety Standards Committee (TRANSSC); and the Waste Safety Standards Committee (WASSC). 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 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.

The English version of the text is the authoritative version.

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1. INTRODUCTION

BACKGROUND

1.1. Radioactive waste is generated in the generation of electricity in nuclear power plants and in the use of radioactive material in industry, research and medicine. The importance of the safe management of radioactive waste for the protection of human health and the environment has long been recognized. The principles and requirements that govern the safety of the management of radioactive waste are presented in The Principles of Radioactive Waste Management [1], Legal and Governmental Infrastructure for Nuclear, Radiation, Radioactive Waste and Transport Safety [2] and Predisposal Management of Radioactive Waste, Including Decommissioning [3].

1.2. Reference [3] establishes requirements for the safe management of radioactive waste prior to its disposal. These requirements are derived from the principles for radioactive waste management established in the Safety Fundamentals publication The Principles of Radioactive Waste Management [1] and include requirements for the protection of human health and the environment and associated responsibilities. Recommendations on the fulfilment of these requirements are provided in this Safety Guide and several associated Safety Guides.

1.3. This Safety Guide provides recommendations on how to meet the safety requirements for the predisposal management of high level radioactive waste, which includes high level waste (HLW) in liquid form and solidified form from the reprocessing of spent fuel and also spent fuel itself, if declared as waste. The predisposal management of radioactive waste includes all the steps in the management of waste prior to its disposal and also includes decommissioning. This Safety Guide provides recommendations to regulatory bodies and other national authorities and operating organizations (operators) on the safe processing of waste and guidance on the properties necessary for waste packages to meet the requirements for handling, transport, storage and disposal. Meeting these requirements will ensure proper planning for and the safe management of HLW in the established nuclear regulatory framework.

1.4. HLW originates primarily from spent fuel. There are two fundamental approaches to managing spent fuel:

- (a) Reprocessing to extract potentially valuable fissile material for recycling and the management of the resulting reprocessing waste (generally known as the ‘closed fuel cycle’);

- (b) The direct disposal of the spent fuel, if it is declared as waste (generally known as the 'once through fuel cycle').

1.5. HLW may include the following: (1) spent fuel (if declared as waste); (2) the radioactive liquid (hereinafter referred to as liquid HLW) from the reprocessing of spent fuel, containing most of the fission products and actinides originally present in the spent fuel, and the waste form (hereinafter referred to as solidified HLW) resulting from the solidification of this material; and (3) other waste with an activity comparable with that of (1) and (2) above. HLW is both heat generating and long lived.

1.6. Programmes for managing HLW may include other waste streams that are directed to an HLW programme. Examples include reactor core components, the structural parts of fuel assemblies or other waste streams that arise from reprocessing and that may be concentrated and added to the liquid HLW for technical or economic reasons.

1.7. Spent fuel may be kept in a storage facility for an extended period pending a decision being made on whether to reprocess it. In addition to the protection of human health and the environment, several considerations will influence the choice of approach, such as: the accumulated amount of spent fuel and the available storage capacity; safety considerations (such as the integrity of the fuel cladding) relating to the long term storage of the fuel; the financial resources available; the state of the waste management systems available; public consultation; and uncertainties about future social and political conditions. If no decision is made on the disposal or reprocessing of the spent fuel it should be ensured that the capability and capacity for storage are adequate.

Processing and storage

1.8. The predisposal management of HLW may include one or more processing steps (e.g. pretreatment, treatment and conditioning). The handling, storage and transport of the waste will be necessary within, between and after such steps. The approaches to be taken for managing the HLW will determine the necessary processing steps (see Annex I).

1.9. The objective of predisposal management is to produce packages of conditioned HLW suitable for safe handling, transport, storage and disposal. If no disposal facility is available for the HLW, assumptions should be made on the requirements for the acceptance of the waste in the future at a repository in order to provide guidance for its predisposal management. In the absence of a disposal facility

it should be ensured that all relevant parties are involved in the discussions that lead to the formulation of the necessary guidance.

Decommissioning

1.10. The decommissioning of a management facility for HLW involves various administrative and technical actions to be taken at the end of its useful life to enable the removal of some or all of the regulatory controls from the facility. Planning should be carried out at an early stage to enable the incorporation of design features to facilitate decommissioning and the specification of appropriate operational measures which, when taken together, should contribute substantially to the safe decommissioning of the facility. Requirements and recommendations for the decommissioning of nuclear facilities of various kinds are provided in Refs [3–6], and these safety standards should be consulted for their applicability to decommissioning activities for HLW.

OBJECTIVE

1.11. The objective of this Safety Guide is to provide regulatory bodies and the operators that generate and manage radioactive waste with recommendations on how to meet the principles and requirements established in Refs [1–3] for the predisposal management of HLW.

SCOPE

1.12. This Safety Guide applies to the predisposal management of HLW as defined in para. 1.5.

1.13. For liquid HLW arising from the reprocessing of spent fuel the recommendations of this Safety Guide apply from when liquid waste from the first extraction process is collected for storage and subsequent processing.

1.14. Recommendations and guidance on the storage of spent fuel, whether or not declared as waste, subsequent to its removal from the storage facility of a reactor are provided in Refs [7–9].

1.15. For spent fuel declared as waste this Safety Guide applies to all activities subsequent to its removal from the storage facility of a reactor and prior to its disposal.

1.16. Requirements pertaining to the transport of spent fuel, whether or not declared as waste, and of all forms of HLW (see para. 1.5) are established in Ref. [10] and related recommendations are presented in Ref. [11].

1.17. For any other type of waste or waste stream this Safety Guide applies when the waste is directed into the HLW stream under the respective predisposal management scheme. If not directed into the HLW stream, low and intermediate level waste streams, including those generated in the predisposal management of HLW, should be managed in accordance with the recommendations given in Ref. [12].

1.18. This Safety Guide provides recommendations on the safety aspects of managing HLW, including the planning, design, construction, commissioning, operation and decommissioning of equipment or facilities for the predisposal management of HLW. It addresses the following elements:

- (a) The characterization and processing (i.e. pretreatment, treatment and conditioning) of HLW;
- (b) The storage of liquid and solidified HLW;
- (c) The storage of conditioned spent fuel.

1.19. Recommendations on the decommissioning of facilities for the predisposal management of HLW are provided in Ref. [4]. Recommendations on safety assessments for HLW facilities are to be included in a Safety Guide on Safety Assessment for Nuclear Fuel Cycle Facilities, Excluding Reactors and Waste Repositories, and particular recommendations on storage will be provided in a Safety Guide on Safe Storage of Radioactive Waste. This Safety Guide provides additional recommendations in these areas only if they are specific to the predisposal management of HLW.

1.20. Unless specific reference is made to one or more categories, the recommendations in this Safety Guide apply generally to all categories of HLW. The possibility of criticality is more significant for spent fuel than it is for other categories of HLW, and should be given appropriate consideration in all activities in which spent fuel is involved. The possibility of criticality involving liquid HLW should, however, also always be considered (see para. 5.3).

STRUCTURE

1.21. Section 2 deals with the protection of human health and the environment and Section 3 with the roles and responsibilities of the regulatory body and the operator.

Section 4 outlines safety considerations in the predisposal management of HLW and Section 5 presents recommendations on the predisposal management of liquid HLW and spent fuel, on the design and operation of facilities and on acceptance requirements. Section 6 provides recommendations on record keeping and reporting and Section 7 deals with safety and environmental assessments. Section 8 is on quality assurance. An appendix outlines the key properties and characteristics of HLW. Annex I presents a summary of practical steps in the predisposal management of HLW. Annexes II and III list site conditions, processes and events for consideration in a safety assessment for external natural phenomena and for external human induced phenomena, respectively. Annex IV lists postulated initiating events (internal phenomena) for consideration in a safety assessment.

2. PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

2.1. The requirements established in Section 2 of Ref. [3] for the protection of human health and the environment apply to the predisposal management of HLW. Activities in the predisposal management of HLW contribute to ensuring that HLW is dealt with in a manner that protects human health and the environment, both now and in the future, without imposing undue burdens on future generations [1]. The predisposal management of HLW should form an essential part of a national system for the management of HLW and it should be ensured that the applicable safety requirements are met.

2.2. In the design of a facility and the planning of practices for the predisposal management of HLW it is required to take into account the need to protect both workers and the public against exposure to radiation, in accordance with the Basic Safety Standards [13], which require that occupational doses be kept below established dose limits and as low as is reasonably achievable (ALARA), economic and social factors being taken into account (Ref. [13], Section 2).

2.3. Owing to the high radionuclide concentrations and high radiation levels associated with HLW, its predisposal management has the potential to give rise to significant exposure to radiation of workers and members of the public. Particular emphasis should therefore be placed on the prevention, detection and mitigation of incidents and accidents in the design, operation and decommissioning of facilities for the management of HLW.

2.4. Careful attention should also be paid to the control of occupational exposure in the design of a facility and in operational practices for the predisposal management of HLW. Doses due to occupational exposure should be maintained ALARA by means of sound operational and engineering practices and administrative controls. Examples of such measures include:

- (a) Thorough planning for and careful execution of activities for the management of HLW, including facilitating the eventual decommissioning of management facilities for HLW;
- (b) Pre-work assessments and training mockups to minimize exposures during operational and maintenance activities;
- (c) The use of remote handling technologies for operational and maintenance activities;
- (d) Establishing controls, such as activity limits, if items are transferred or removed from areas of higher contamination to areas of lower contamination.

2.5. Releases of radioactive material to the environment from predisposal management facilities for HLW should be controlled in accordance with the recommendations provided in Ref. [14] and the limits and conditions set by the regulatory body.

2.6. The adequacy of controls provided to limit the exposure of workers and the public should, where appropriate, be verified by means of personal, area and discharge monitoring.

2.7. The primary safety concern with HLW is the radiological hazard. However, hazards to human health and the environment due to its other physical and chemical characteristics should also be taken into account in designing and operating facilities for the predisposal management of HLW. Protection from non-radiological hazards should be provided in accordance with the relevant standards on health and safety and environmental protection.

2.8. The management of HLW is required to be carried out in such a manner that no undue burdens are imposed on future generations (Ref. [1]; Ref. [3], para. 2.1). Decision making on the reprocessing or direct disposal of spent fuel, for example, is often postponed if no disposal facility is available. In practice, therefore, spent fuel is stored in an engineered facility, the design, operation and safety assessment of which should proceed in accordance with the recommendations and guidance given in Refs [7–9], respectively.

2.9. Operators responsible for the predisposal management of HLW should maintain an awareness of the potential national strategies for the disposal of HLW,

and should study processes for its eventual disposal that are consistent with national planning. Programmes should be undertaken such that the generation of liquid HLW and the need for its long term storage are minimized to the extent practicable. Consideration should be given to stabilizing the waste while decisions on its disposal are pending. This should be in a form that is likely to meet the waste acceptance criteria for a future repository and that will provide greater protection to present and future generations.

2.10. Whichever strategy is chosen, all facilities involved in the predisposal management of HLW should be designed and operated, and all activities concerned should be conducted, in a manner that is consistent with the hazards of the particular form of the HLW. If treatment or an initial conditioning of the liquid HLW is performed, for example, to provide a safer form and to reduce the probability of its dispersal, consideration should be given to its subsequent processing and its compatibility with the final form of the conditioned waste. Consideration should also be given to all hazards associated with the techniques employed to stabilize waste.

2.11. “The generation of radioactive waste shall be kept to the minimum practicable, in terms of both its activity and volume...” (Ref. [1], para. 324). Minimizing the generation of HLW, if possible, should be a goal of the process in which it is generated. It should be a general goal to reduce the volume and activity of the secondary waste streams that can arise from the management activities for HLW. Elements that should be considered for reducing the amounts of such waste generated include the use of a well designed process, efficient operations and a well conceived and executed decommissioning of the facility.

2.12. A safety culture is required to be fostered and maintained in all organizations involved in the predisposal management of HLW, from its generation to its eventual disposal, so as to encourage an enquiring, learning and self-disciplined attitude to protection and safety and to discourage complacency (Ref. [13], para. 2.28; Ref. [15]).

3. ROLES AND RESPONSIBILITIES

GENERAL CONSIDERATIONS

3.1. The predisposal management of HLW is required to take place within an appropriate national legal framework that provides a clear allocation of responsibilities [1] and effective regulatory control of the facilities and activities

concerned (Ref. [2]; Ref. [3], paras 3.5–3.9). The national legal framework will also permit compliance with other national and international laws. Although laws are normally of a general nature, the national legal system may permit the issuing of site specific regulations for the predisposal management of HLW. Requirements in respect of the responsibilities for establishing such a framework and the responsibilities of the regulatory body for ensuring the safety of the predisposal management of HLW are established in Ref. [2].

3.2. The predisposal management of HLW may involve the transfer of radioactive waste from one operator to another or the processing of HLW in another State. The established legal framework should include provisions to ensure that there is a clear allocation of responsibility for safety during the entire predisposal management process for HLW, including any transfer between operators. Consideration should also be given to the decommissioning of any facility at which HLW is managed. This continuity of responsibility for safety should be ensured by means of appropriate authorizations by the regulatory body (e.g. by means of a licence or a sequence of licences, in accordance with the national legal framework and agreements among the States involved in the transboundary movement of HLW).

3.3. An individual governmental organization should not be given both operational and regulatory responsibility for radioactive waste management. However, if this cannot be avoided, the regulatory and the operational responsibilities should be clearly specified and functionally separated.

RESPONSIBILITIES OF THE REGULATORY BODY

3.4. For the predisposal management of HLW, as in all areas of its statutory obligations, the regulatory body is required to act within the national legal framework, to define policies, safety principles and associated criteria and to establish requirements to serve as the basis for its regulatory actions (Ref. [2], paras 3.1 and 3.2). The regulatory body is required to provide guidance to operators on meeting the requirements for the predisposal management of HLW. In fulfilling its obligations the regulatory body is required to carry out a number of the functions that are established in Ref. [2], the primary ones being:

- (a) To review and assess submissions on safety from the operators;
- (b) To issue, amend, suspend or revoke authorizations;
- (c) To carry out regulatory inspections;
- (d) To ensure that corrective actions are taken if unsafe or potentially unsafe conditions are detected;

- (e) To take the necessary enforcement action in the event of a violation of the regulatory requirements.

3.5. Recommendations on the review and assessment of facilities and activities involved in the management of HLW by the regulatory body are provided in Ref. [16]. Recommendations on the documentation that the regulatory body should require the operator of a nuclear facility to produce for the regulatory process are given in Ref. [17].

3.6. The regulatory body should prepare guidelines for the decommissioning of management facilities for HLW as early as possible. The operator should follow such guidelines in choosing design options and operating practices to facilitate decommissioning.

3.7. Owing to the potentially long time periods between the conditioning of HLW and its disposal, particular attention should be paid to ensuring that the necessary human, technical and financial resources will be available when required and that the appropriate information is available. The regulatory body should ensure that a means for obtaining the resources is in place, as appropriate, and that the necessary records are prepared and maintained for an appropriate period of time. A listing of the necessary records is included in Ref. [17].

3.8. The regulatory body should typically provide guidance to the operators carrying out the predisposal management of HLW on:

- (a) Criteria for the protection of human health and the environment;
- (b) Requirements for nuclear safety;
- (c) Requirements for the control of effluent discharges;
- (d) Criteria for the characterization and classification of radioactive waste;
- (e) Strategies for the management of radioactive waste;
- (f) Acceptance criteria for the long term storage and/or disposal of radioactive waste;
- (g) Processes and procedures for the granting of a licence or another type of authorization;
- (h) Procedures for the modification of plant or procedures;
- (i) Policies and procedures used by the regulatory body for verifying compliance and enforcement;
- (j) The timing and content of periodic reports to be submitted by the operator to the regulatory body;
- (k) Safety culture;
- (l) Quality assurance.

3.9. The regulatory body should verify the key aspects of operations for the predisposal management of HLW to be performed by the operator, such as the compliance of the conditioned HLW package with the acceptance requirements of the disposal facility or long term storage facility.

3.10. It is expected that the government will consult the regulatory body on all matters relating to policy and strategy on the safety of HLW management, and the regulatory body should provide such advice on matters relating to the safety of facilities and activities, and on protection and safety in emergencies (Ref. [2], paras 3.3 and 6.6).

RESPONSIBILITIES OF OPERATORS

3.11. Prior to commencing the construction or significant modification of any facility for the predisposal management of HLW, the operator is required to submit to the regulatory body an application detailing the proposed design and operational practices together with a safety assessment, in accordance with regulatory requirements (Ref. [2], Section 5). This submission should justify the proposed practices and should demonstrate their safety by means of an assessment as described in Section 7. Prior to the regulatory body's granting of an authorization to commence operations using radioactive material, the operator should carry out pre-operational and commissioning tests, as required by the regulatory body, in order to demonstrate compliance with the requirements for design and other safety requirements.

3.12. The operator may process, store and/or dispose of HLW in an approved manner using its own facilities or may transfer waste at some point to another operator. In so doing, the operator should identify suitable destinations and should ensure that any transfer of HLW is made only to authorized organizations. It should be the responsibility of the operator to ensure that radioactive waste is transported safely and in accordance with national and international regulations for the safe transport of radioactive material [10]. The operator is responsible for the safety of all activities in the predisposal management of waste, even if the work is contracted to a third party. Any transport of waste to other States must comply with international obligations such as Article 27 of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management [18]. The operator should also have full responsibility for ensuring that the waste packages comply with the acceptance requirements for the disposal of HLW. If no such requirements apply, the operator should give thorough consideration to the compatibility of the waste package with the anticipated acceptance requirements for disposal, so as to provide reasonable assurance that the conditioned HLW will be accepted for disposal.