

IAEA Safety Standards

for protecting people and the environment

Storage of Radioactive Waste

Safety Guide

No. WS-G-6.1



IAEA

International Atomic Energy Agency

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STORAGE OF RADIOACTIVE WASTE

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STORAGE OF RADIOACTIVE WASTE

INTERNATIONAL ATOMIC ENERGY AGENCY
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FOREWORD

by Mohamed ElBaradei
Director General

The IAEA's Statute authorizes the Agency to establish safety standards to protect health and minimize danger to life and property — standards which the IAEA must use in its own operations, and which a State can apply by means of its regulatory provisions for nuclear and radiation safety. A comprehensive body of safety standards under regular review, together with the IAEA's assistance in their application, has become a key element in a global safety regime.

In the mid-1990s, a major overhaul of the IAEA's safety standards programme was initiated, with a revised oversight committee structure and a systematic approach to updating the entire corpus of standards. The new standards that have resulted are of a high calibre and reflect best practices in Member States. With the assistance of the Commission on Safety Standards, the IAEA is working to promote the global acceptance and use of its safety standards.

Safety standards are only effective, however, if they are properly applied in practice. The IAEA's safety services — which range in scope from engineering safety, operational safety, and radiation, transport and waste safety to regulatory matters and safety culture in organizations — assist Member States in applying the standards and appraise their effectiveness. These safety services enable valuable insights to be shared and I continue to urge all Member States to make use of them.

Regulating nuclear and radiation safety is a national responsibility, and many Member States have decided to adopt the IAEA's safety standards for use in their national regulations. For the Contracting Parties to the various international safety conventions, IAEA standards provide a consistent, reliable means of ensuring the effective fulfilment of obligations under the conventions. The standards are also applied by designers, manufacturers and operators around the world to enhance nuclear and radiation safety in power generation, medicine, industry, agriculture, research and education.

The IAEA takes seriously the enduring challenge for users and regulators everywhere: that of ensuring a high level of safety in the use of nuclear materials and radiation sources around the world. Their continuing utilization for the benefit of humankind must be managed in a safe manner, and the IAEA safety standards are designed to facilitate the achievement of that goal.

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1. INTRODUCTION

BACKGROUND

1.1. Radioactive waste is generated in a broad range of activities involving a wide variety of radioactive materials associated with, for example, the operation of nuclear facilities, the use of sealed radioactive sources in industry, the use of human made radionuclides in hospitals and laboratories, and the decommissioning of such facilities. The physical, chemical and radiological characteristics of the waste arising from these activities differ widely.

1.2. The principles and requirements for the safe management of radioactive waste for the protection of human health and the environment are established in the IAEA safety standards: The Fundamental Safety Principles [1], Legal and Governmental Infrastructure for Nuclear, Radiation, Radioactive Waste and Transport Safety [2], Predisposal Management of Radioactive Waste, Including Decommissioning [3] and the International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources (BSS) [4]. Recommendations on the application of these principles through the fulfilment of these requirements as they pertain to radioactive waste storage are provided in this Safety Guide and several associated Safety Guides [5–7].

1.3. Following its generation, untreated radioactive waste may be subject to a number of waste management processes prior to its disposal such as handling, treatment and conditioning. During these processing steps, radioactive waste may be subject to storage at a number of stages. Hence, radioactive waste will be stored in processed and unprocessed forms and for varying periods of time.

1.4. There are many reasons why it may be appropriate to store radioactive waste for varying periods of time. Examples include the following:

- (a) To allow for the decay of short lived radionuclides to a level at which the radioactive waste can be released from regulatory control (clearance) or authorized for discharge, or recycling and reuse;
- (b) To collect and accumulate a sufficient amount of radioactive waste prior to its transfer to another facility for treatment and conditioning;
- (c) To collect and accumulate a sufficient amount of radioactive waste prior to its disposal;

- (d) To reduce the heat generation rate of high level radioactive waste prior to its disposal and, in some cases, prior to steps in its predisposal management;
- (e) To provide long term storage of radioactive waste in those States lacking a suitable disposal facility.

Examples (a), (b) and (c) are usually encountered at small storage facilities for radioactive waste, where storage is incidental to the primary purpose of the facility. Examples (d) and (e) are usually associated with larger facilities undertaking the treatment and storage of waste from nuclear fuel cycle facilities and from centralized facilities at which the waste from many small users of radioactive sources is collected and processed.

1.5. The period of storage may be highly variable and may be only a few days, weeks or months in the case of storage for decay or storage prior to the transfer of waste to another facility. Extended storage periods of many years may be necessary in the case of the storage of high level waste for cooling or for the long term storage of radioactive waste for which there is no disposal option yet available.

1.6. The storage facility may be located at the facility generating the waste, such as a nuclear power plant, a hospital or a laboratory, or it may comprise a separate entity such as a centralized facility or a national treatment and storage facility. Storage facilities can range from secure cabinets and closets at laboratories up to large facilities built for serving a nuclear power plant.

OBJECTIVE

1.7. 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 safety requirements established in Ref. [3] for the safe storage of radioactive waste. The guidance provided is applicable to all storage facilities, although there are separate sections for small and large storage facilities. The storage of radioactive waste means the holding of radioactive waste in a facility that provides for its containment, with the intention of retrieval.

SCOPE

1.8. This Safety Guide applies to the storage of solid, liquid and gaseous radioactive wastes in a wide range of facilities, including those at which waste is generated, treated and conditioned. The storage facility could range from a secure cupboard or closet in a laboratory, through to larger designated areas such as rooms or buildings, up to and including a large site dedicated to the storage of radioactive waste.

1.9. This Safety Guide does not address:

- (a) The storage of waste arising from the mining and processing of uranium and thorium ores and minerals;
- (b) The storage of other waste containing elevated concentrations of naturally occurring radionuclides and waste from mineral processing activities;
- (c) The wet or dry storage of spent nuclear fuel, which is addressed in Refs [6, 8–10].

1.10. A wide variety of waste types and storage needs may be encountered in practice, for example, in terms of the storage duration, radioactive inventory, radionuclide half-lives and associated radiological hazards. The guidance given is therefore expected to be applied in accordance with the specific safety requirements appropriate to each storage situation. In a graded approach to the application of the safety requirements [11, 12], the implementation of safety measures should be commensurate with the nature and level of the hazard associated with the waste types and the radionuclide inventory. The regulatory body should provide guidance on the extent to which the various aspects of this Safety Guide are relevant and appropriate for a particular storage facility.

1.11. This Safety Guide is intended to apply to new facilities but it may also be applied to existing facilities. Dependent on the relative risk, a safety review of existing facilities should be conducted to determine whether steps to improve their safety may be required.

1.12. There may be significant non-radiological hazards associated with the storage of radioactive waste. Limited guidance is given in this Safety Guide on measures to be taken in this regard. If non-radiological properties such as corrosiveness, flammability, explosiveness, toxicity and pathogenicity may affect the safe management of the radiological hazard, then these should be

taken into consideration during the safety assessment. Guidance in respect of non-radiological hazards should be sought from the relevant regulatory body in the areas of industrial health and safety and environmental protection.

STRUCTURE

1.13. This Safety Guide provides guidance that is specific to small and to large storage facilities and guidance that is common to both small and large facilities. Sections 2 and 3 address, respectively, the protection of human health and the environment, and roles and responsibilities. Section 4 outlines general safety considerations in the storage of radioactive waste that are common to both small and large storage facilities. Sections 5 and 6 provide guidance on safety in the design and operation of small and large storage facilities, respectively. Information on safety assessment as applied to the storage of radioactive waste is provided in the Appendix.

2. PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

2.1. Requirements for radiation protection are established in the BSS [4]. In particular, the radiation protection of any persons who are exposed as a consequence of the storage of radioactive waste is required to be optimized (see paras 2.24 and 2.25 of the BSS [4]), with due regard to dose constraints, and the exposures of individuals are required to be kept within the specified dose limits.

2.2. The storage of radioactive waste must ensure that both human health and the environment will be protected, both now and in the future, without imposing undue burdens on future generations [1]. The safety requirements established in Section 2 of Ref. [3] relating to the protection of human health and the environment are applicable to the storage of radioactive waste.

2.3. In the design and operation of storage facilities for radioactive waste, it is required to provide for the protection of workers, the public and the environment in accordance with the requirements and principles of Refs [1, 4], such that:

- (a) Radiation doses to workers and the public as a consequence of waste storage activities do not exceed the relevant limits established in the BSS;
- (b) Storage facilities are designed and operated in such a way that the radiation protection of workers and the public is optimized in accordance with the requirements of the BSS;
- (c) The consequences of any foreseeable fault or accident condition would be such that protective actions are optimized as required by the BSS.

2.4. Discharges to the environment from storage facilities should be controlled in accordance with the guidance provided in Ref. [13] and any facility specific conditions imposed by the regulatory body.

2.5. The adequacy of control measures taken to limit the exposure of workers should be verified by means of individual monitoring and area monitoring.

2.6. In the generation and storage of waste, as well as subsequent management steps, a safety culture should be fostered and maintained to encourage a questioning and learning attitude to protection and safety and to discourage complacency [4, 14].

3. ROLES AND RESPONSIBILITIES

GENERAL

3.1. Storage of waste should be undertaken within an appropriate national legal framework that provides for a clear allocation of responsibilities [2] and ensures the effective regulatory control of facilities and activities [3]. The national legal framework should also ensure the fulfilment of other relevant national and international obligations. Requirements for establishing a national framework and the responsibilities of the regulatory body for ensuring safety, including the safety of the storage of radioactive waste, are established in Ref. [2]. International obligations, as applicable, are established in the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management [15].

3.2. The management of radioactive waste may entail the transfer of waste from one operator to another. The legal framework should include provisions to ensure a clear allocation of responsibility for safety throughout the entire process of predisposal management, in particular with respect to storage, and including any transfer between operators. The continuity of responsibility for safety should be ensured by means of authorization by the regulatory body. For transfers between States, authorizations from each of the national regulatory bodies concerned should be obtained.

3.3. The regulatory and operational responsibilities for radioactive waste management should be clearly specified and functionally separated. A single organization should not be given both the operational and the regulatory responsibility for waste management.

RESPONSIBILITIES OF THE GOVERNMENT

3.4. The government is responsible for setting national policies and strategies for the management of radioactive waste and for providing the legal framework required to implement these policies and strategies. The policies and strategies for waste management should address the types of storage facility that are appropriate for the national waste inventory.

3.5. The government should consult interested parties (i.e. those involved in or affected by waste management activities) on matters relating to the development of policies and strategies that affect the safety of large storage facilities for radioactive waste.

RESPONSIBILITIES OF THE REGULATORY BODY

3.6. The regulatory body should provide guidance to operators on requirements relating to the storage of radioactive waste and the clearance of material (i.e. removal from any further regulatory control). Responsibilities may include contributing to the technical input for defining policies, safety principles and associated criteria and establishing regulations or conditions to serve as the basis of its regulatory actions (see Ref. [3], paras 3.1 and 3.2). In fulfilling its obligations, the regulatory body should fulfil the relevant functions that are established in Ref. [2].

3.7. Given the wide range of potential hazards, depending on the nature of the facility, a graded regulatory approach should be adopted that is commensurate with the level of hazard. Authorization in the form of registration may be sufficient for many small storage operations; the authorization of a small storage facility should be covered by the authorization for the facility in which radiation sources are used. For large storage facilities, licensing will probably be necessary to ensure the required level of control.

3.8. General recommendations on the review and assessment of the safety of nuclear facilities, including facilities for the storage of radioactive waste, by the regulatory body are provided in Ref. [16]. Recommendations on the documentation for the regulatory process for nuclear facilities are provided in Ref. [17]. Guidance concerning the elements of the national regulatory infrastructure that is necessary to achieve an appropriate level of protection and safety for radiation sources used in medicine, industry, agriculture, research and education is provided in Ref. [18].

3.9. Since waste may be stored for extended periods of time prior to its disposal, the regulatory body should confirm that the operator is providing the necessary human, technical and financial resources for the lifetime of the storage facility, to the extent that such confirmation is within its statutory obligations.

3.10. The regulatory body should periodically verify the acceptability of key aspects of the storage operation, such as the keeping of records, inventories and material transfer records; compliance with package acceptance criteria for storage; maintenance of the facility; and surveillance and monitoring. This may be carried out, for example, by routine inspections of the storage facility and formal audits of the operator's documentation. The regulatory body should confirm that the necessary records are prepared and that they are maintained for an appropriate period of time. A list of such records is included in Ref. [17].

RESPONSIBILITIES OF OPERATORS

3.11. The operator is responsible for the safety of all activities in the storage of radioactive waste and for the implementation of the programmes and procedures necessary to ensure safety. In accordance with the graded approach, the programmes and procedures necessary to ensure safety will generally be less extensive for the operator of a small facility.

3.12. The responsibilities of the operator of a large storage facility for radioactive waste would typically include:

- (a) Making an application to the regulatory body to site, construct, operate, modify or decommission a waste storage facility;
- (b) Conducting appropriate environmental assessments and safety assessments to support the application for a licence;
- (c) Operating the facility in accordance with the licence conditions and the applicable regulations;
- (d) Developing and applying acceptance criteria for the storage of radioactive waste;
- (e) Providing periodic reports to the regulatory body in relation to the safety of the facility (e.g. on the current inventory and the estimated future inventory and waste transfers into and out of the facility).

Not all of the items listed here may apply to small operators. For example, a small operator may not be expected to go through a siting process.

3.13. Prior to the authorization of a facility for the storage of radioactive waste, the operator should provide the regulatory body with plans for the long term management of the radioactive waste being stored. The public, especially communities located near the storage facility, should be informed of these plans.

3.14. The operator should demonstrate the safety of the facility by means of a safety assessment that is commensurate with the hazards envisaged. For smaller and simpler facilities, the regulatory body may set generic inventory limits instead of requiring a full safety assessment. Guidance on preparing the safety assessment for facilities for the predisposal management of radioactive waste is provided in Refs [5–7]. Further information on safety assessment for the storage of radioactive waste is provided in the Appendix.

3.15. The operator of a storage facility for radioactive waste should use the safety assessment to propose facility specific operational limits and conditions. The operator may wish to set an administrative margin below the operational limits approved by the regulatory body as an operational target to remain within the approved operational limits and conditions.

3.16. The operator should determine the maximum quantities and concentrations of the radioactive materials or other hazardous materials that

may be safely discharged to the environment and should document such discharges.

3.17. At an early stage in the lifetime of a waste storage facility, the operator of the facility should prepare plans for its eventual decommissioning. For new facilities, decommissioning should be taken into consideration at the design stage. Guidance on decommissioning is provided in Refs [19, 20].

3.18. The operator of a large storage facility for radioactive waste should carry out pre-operational tests and commissioning tests to demonstrate compliance with the safety requirements established by the regulatory body.

3.19. As appropriate to the hazards associated with the waste storage facility, the operator of the facility should prepare plans and implement programmes for personnel monitoring, area monitoring and environmental monitoring, and for emergency preparedness and response.

3.20. The operator of a waste storage facility should put in place appropriate mechanisms to ensure that sufficient financial resources are available to undertake all necessary tasks throughout the lifetime of the storage facility, including its decommissioning [2].

MANAGEMENT SYSTEM

3.21. A management system should be established, implemented, assessed and continually improved [11] by the operator and should be applied to all those stages of the storage of radioactive waste that have a bearing on safety. It should be aligned with the goals of the organization and should contribute to their achievement. The scope of the management system should include the siting, design, operation and maintenance of a storage facility for radioactive waste. The management system should be designed to ensure that the safety of the stored waste and that of the facility itself is maintained and that the quality of the records and of subsidiary information such as the marking and labelling of waste packages is preserved. A management system should also contain provision to ensure that the achievement of its goals can be demonstrated.

3.22. The management system should be applied to the processing of waste to ensure that all waste acceptance requirements are fulfilled for storage, and for disposal to the extent possible. General guidance on management systems for

each stage in the lifetime of a storage facility for radioactive waste is provided in Ref. [11].

4. COMMON SAFETY CONSIDERATIONS FOR WASTE STORAGE FACILITIES

4.1. A storage facility for radioactive waste should be designed and operated to ensure that the radiation protection of workers and the public is optimized as required by the BSS and to ensure the containment and facilitate the retrieval of the waste.

4.2. To the extent practicable, radioactive waste should be stored according to recommendations for passive safety, including the following:

- (a) The radioactive material should be immobile;
- (b) The waste form and its container should be physically and chemically stable;
- (c) Energy should be removed from the waste form;
- (d) A multibarrier approach should be adopted in ensuring containment;
- (e) The waste form and its container should be resistant to degradation;
- (f) The waste storage environment should optimize the lifetime of the waste package;
- (g) The need for active safety systems to ensure safety should be minimized;
- (h) The need for monitoring and maintenance to ensure safety should be minimized;
- (i) The need for human intervention to ensure safety should be minimized;
- (j) The waste storage building should be resistant to foreseeable hazards;
- (k) Access to the waste storage building should be provided for response to incidents;
- (l) There should be no need for prompt corrective action in the event of an incident;
- (m) The waste packages should be able to be inspected;
- (n) The waste packages should be retrievable for inspection or reworking;
- (o) The lifetime of the waste storage building should be appropriate for the storage period prior to disposal of the waste;
- (p) The waste storage facility should enable the retrieval of waste;
- (q) The waste package should be acceptable for final disposal of the waste.

4.3. For the storage of radioactive waste, a variety of records should be compiled, managed and maintained in accordance with a management system (see paras 3.21, 3.22). The scope and detail of the records will depend on the hazard associated with the facility and on the complexity of the operations and activities.

4.4. The scope and detail of the safety documentation should be appropriate to the hazards, the radioactive inventory and the characteristics of the waste. As applicable, para. 6.5 provides guidance on the content of safety documentation.

4.5. A safety assessment comprises an evaluation of the aspects of design and operation of a storage facility for radioactive waste to ensure the protection of workers and the public and the protection of the environment under normal conditions and in accident situations. The safety assessment should be periodically re-evaluated and, if necessary, revised to reflect changes in conditions, facilities or procedures.

4.6. Waste storage should be planned for on the basis of documented information (i.e. waste forecasts) on the quantities and types of waste that could be generated.

4.7. Storage facilities and waste packages should provide for the safe storage of waste by taking account of the waste form (i.e. solid, liquid or gas), its radionuclide content and half-lives, its activity concentrations, the total radioactive inventory, its non-radiological characteristics and the expected duration of storage. The design features and facility operations should be such as to ensure that the waste can be received, handled, stored and retrieved without undue occupational and public radiation exposure or environmental impact.

4.8. Waste storage facilities should be designed and operated to minimize the probability and consequences of incidents and accidents.

4.9. Non-radiological hazards due to physical, chemical and pathogenic characteristics of waste should also be considered in the design and operation of storage facilities, as interactions of wastes may have consequences for human health and the environment. Such interactions could include generation of noxious gases by biological processes and generation of corrosive substances by chemical processes.