

IAEA Safety Standards

for protecting people and the environment

Monitoring and Surveillance of Radioactive Waste Disposal Facilities

Specific Safety Guide

No. SSG-31



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International Atomic Energy Agency



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IAEA SAFETY STANDARDS

Under the terms of Article III of its Statute, the IAEA is authorized to establish or adopt standards of safety for protection of health and minimization of danger to life and property, and to provide for the application of these standards.

The publications by means of which the IAEA establishes standards are issued in the **IAEA Safety Standards Series**. This series covers nuclear safety, radiation safety, transport safety and waste safety. The publication categories in the series are **Safety Fundamentals**, **Safety Requirements** and **Safety Guides**.

Information on the IAEA's safety standards programme is available on the IAEA Internet site

<http://www-ns.iaea.org/standards/>

The site provides the texts in English of published and draft safety standards. The texts of safety standards issued in Arabic, Chinese, French, Russian and Spanish, the IAEA Safety Glossary and a status report for safety standards under development are also available. For further information, please contact the IAEA at: Vienna International Centre, PO Box 100, 1400 Vienna, Austria.

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MONITORING AND
SURVEILLANCE OF
RADIOACTIVE WASTE
DISPOSAL FACILITIES



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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".

IAEA SAFETY STANDARDS SERIES No. SSG-31

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DISPOSAL FACILITIES

SPECIFIC SAFETY GUIDE

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2014

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FOREWORD

by Yukiya Amano
Director General

The IAEA's Statute authorizes the Agency to “establish or adopt... standards of safety for protection of health and minimization of danger to life and property” — standards that the IAEA must use in its own operations, and which States can apply by means of their regulatory provisions for nuclear and radiation safety. The IAEA does this in consultation with the competent organs of the United Nations and with the specialized agencies concerned. A comprehensive set of high quality standards under regular review is a key element of a stable and sustainable global safety regime, as is the IAEA's assistance in their application.

The IAEA commenced its safety standards programme in 1958. The emphasis placed on quality, fitness for purpose and continuous improvement has led to the widespread use of the IAEA standards throughout the world. The Safety Standards Series now includes unified Fundamental Safety Principles, which represent an international consensus on what must constitute a high level of protection and safety. With the strong support of the Commission on Safety Standards, the IAEA is working to promote the global acceptance and use of its standards.

Standards are only effective if they are properly applied in practice. The IAEA's safety services encompass design, siting and engineering safety, operational safety, radiation safety, safe transport of radioactive material and safe management of radioactive waste, as well as governmental organization, regulatory matters and safety culture in organizations. These safety services assist Member States in the application of the standards and enable valuable experience and insights to be shared.

Regulating safety is a national responsibility, and many States have decided to adopt the IAEA's standards for use in their national regulations. For 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 regulatory bodies and operators around the world to enhance safety in nuclear power generation and in nuclear applications in medicine, industry, agriculture and research.

Safety is not an end in itself but a prerequisite for the purpose of the protection of people in all States and of the environment — now and in the future. The risks associated with ionizing radiation must be assessed and controlled without unduly limiting the contribution of nuclear energy to equitable and sustainable development. Governments, regulatory bodies and operators everywhere must ensure that nuclear material and radiation sources are used beneficially, safely and ethically. The IAEA safety standards are designed to facilitate this, and I encourage all Member States to make use of them.

THE IAEA SAFETY STANDARDS

BACKGROUND

Radioactivity is a natural phenomenon and natural sources of radiation are features of the environment. Radiation and radioactive substances have many beneficial applications, ranging from power generation to uses in medicine, industry and agriculture. The radiation risks to workers and the public and to the environment that may arise from these applications have to be assessed and, if necessary, controlled.

Activities such as the medical uses of radiation, the operation of nuclear installations, the production, transport and use of radioactive material, and the management of radioactive waste must therefore be subject to standards of safety.

Regulating safety is a national responsibility. However, radiation risks may transcend national borders, and international cooperation serves to promote and enhance safety globally by exchanging experience and by improving capabilities to control hazards, to prevent accidents, to respond to emergencies and to mitigate any harmful consequences.

States have an obligation of diligence and duty of care, and are expected to fulfil their national and international undertakings and obligations.

International safety standards provide support for States in meeting their obligations under general principles of international law, such as those relating to environmental protection. International safety standards also promote and assure confidence in safety and facilitate international commerce and trade.

A global nuclear safety regime is in place and is being continuously improved. IAEA safety standards, which support the implementation of binding international instruments and national safety infrastructures, are a cornerstone of this global regime. The IAEA safety standards constitute a useful tool for contracting parties to assess their performance under these international conventions.

THE IAEA SAFETY STANDARDS

The status of the IAEA safety standards derives from the IAEA's Statute, which authorizes the IAEA to establish or adopt, in consultation and, where appropriate, in collaboration with the competent organs of the United Nations and with the specialized agencies concerned, standards of safety for protection of health and minimization of danger to life and property, and to provide for their application.

With a view to ensuring the protection of people and the environment from harmful effects of ionizing radiation, the IAEA safety standards establish fundamental safety principles, requirements and measures to control the radiation exposure of people and the release of radioactive material to the environment, to restrict the likelihood of events that might lead to a loss of control over a nuclear reactor core, nuclear chain reaction, radioactive source or any other source of radiation, and to mitigate the consequences of such events if they were to occur. The standards apply to facilities and activities that give rise to radiation risks, including nuclear installations, the use of radiation and radioactive sources, the transport of radioactive material and the management of radioactive waste.

Safety measures and security measures¹ have in common the aim of protecting human life and health and the environment. Safety measures and security measures must be designed and implemented in an integrated manner so that security measures do not compromise safety and safety measures do not compromise security.

The IAEA safety standards reflect an international consensus on what constitutes a high level of safety for protecting people and the environment from harmful effects of ionizing radiation. They are issued in the IAEA Safety Standards Series, which has three categories (see Fig. 1).

Safety Fundamentals

Safety Fundamentals present the fundamental safety objective and principles of protection and safety, and provide the basis for the safety requirements.

Safety Requirements

An integrated and consistent set of Safety Requirements establishes the requirements that must be met to ensure the protection of people and the environment, both now and in the future. The requirements are governed by the objective and principles of the Safety Fundamentals. If the requirements are not met, measures must be taken to reach or restore the required level of safety. The format and style of the requirements facilitate their use for the establishment, in a harmonized manner, of a national regulatory framework. Requirements, including numbered ‘overarching’ requirements, are expressed as ‘shall’ statements. Many requirements are not addressed to a specific party, the implication being that the appropriate parties are responsible for fulfilling them.

¹ See also publications issued in the IAEA Nuclear Security Series.

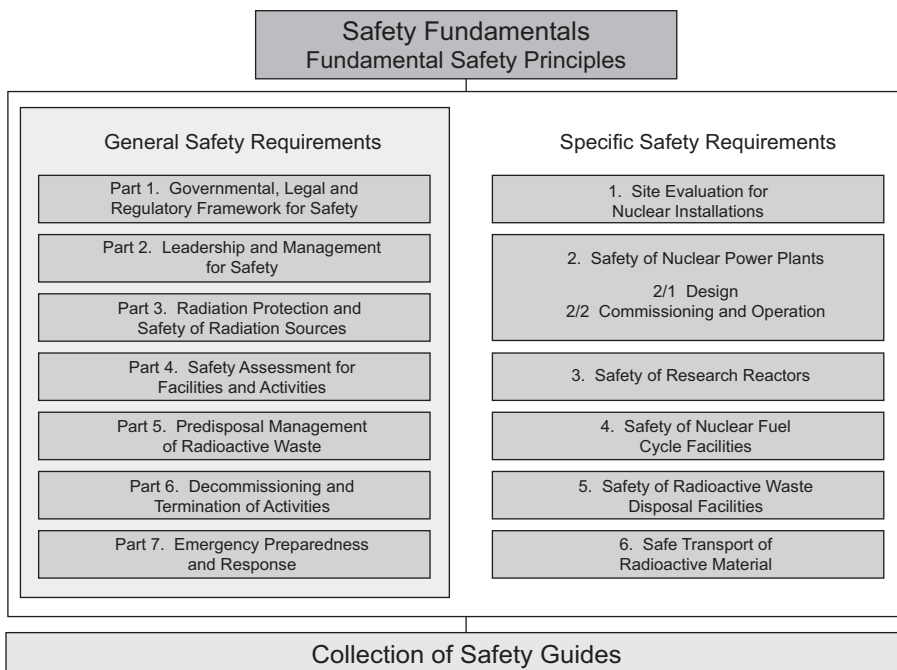


FIG. 1. The long term structure of the IAEA Safety Standards Series.

Safety Guides

Safety Guides provide recommendations and guidance on how to comply with the safety requirements, indicating an international consensus that it is necessary to take the measures recommended (or equivalent alternative measures). The Safety Guides present international good practices, and increasingly they reflect best practices, to help users striving to achieve high levels of safety. The recommendations provided in Safety Guides are expressed as ‘should’ statements.

APPLICATION OF THE IAEA SAFETY STANDARDS

The principal users of safety standards in IAEA Member States are regulatory bodies and other relevant national authorities. The IAEA safety standards are also used by co-sponsoring organizations and by many organizations that design, construct and operate nuclear facilities, as well as organizations involved in the use of radiation and radioactive sources.

The IAEA safety standards are applicable, as relevant, throughout the entire lifetime of all facilities and activities — existing and new — utilized for peaceful purposes and to protective actions to reduce existing radiation risks. They can be used by States as a reference for their national regulations in respect of facilities and activities.

The IAEA's Statute makes the safety standards binding on the IAEA in relation to its own operations and also on States in relation to IAEA assisted operations.

The IAEA safety standards also form the basis for the IAEA's safety review services, and they are used by the IAEA in support of competence building, including the development of educational curricula and training courses.

International conventions contain requirements similar to those in the IAEA safety standards and make them binding on contracting parties. The IAEA safety standards, supplemented by international conventions, industry standards and detailed national requirements, establish a consistent basis for protecting people and the environment. There will also be some special aspects of safety that need to be assessed at the national level. For example, many of the IAEA safety standards, in particular those addressing aspects of safety in planning or design, are intended to apply primarily to new facilities and activities. The requirements established in the IAEA safety standards might not be fully met at some existing facilities that were built to earlier standards. The way in which IAEA safety standards are to be applied to such facilities is a decision for individual States.

The scientific considerations underlying the IAEA safety standards provide an objective basis for decisions concerning safety; however, decision makers must also make informed judgements and must determine how best to balance the benefits of an action or an activity against the associated radiation risks and any other detrimental impacts to which it gives rise.

DEVELOPMENT PROCESS FOR THE IAEA SAFETY STANDARDS

The preparation and review of the safety standards involves the IAEA Secretariat and four safety standards committees, for nuclear safety (NUSSC), radiation safety (RASSC), the safety of radioactive waste (WASSC) and the safe transport of radioactive material (TRANSSC), and a Commission on Safety Standards (CSS) which oversees the IAEA safety standards programme (see Fig. 2).

All IAEA Member States may nominate experts for the safety standards committees and may provide comments on draft standards. The membership of the Commission on Safety Standards is appointed by the Director General and

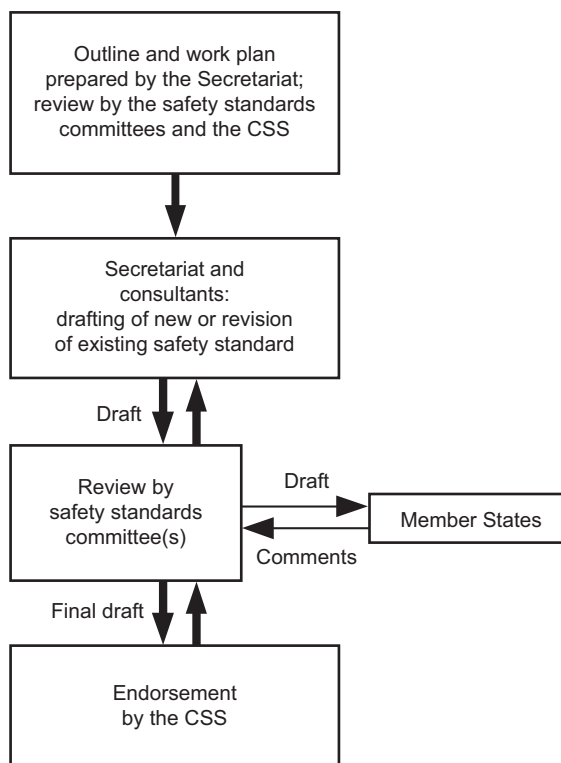


FIG. 2. The process for developing a new safety standard or revising an existing standard.

includes senior governmental officials having responsibility for establishing national standards.

A management system has been established for the processes of planning, developing, reviewing, revising and establishing the IAEA safety standards. It articulates the mandate of the IAEA, the vision for the future application of the safety standards, policies and strategies, and corresponding functions and responsibilities.

INTERACTION WITH OTHER INTERNATIONAL ORGANIZATIONS

The findings of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) and the recommendations of international expert bodies, notably the International Commission on Radiological Protection (ICRP), are taken into account in developing the IAEA safety standards. Some

safety standards are developed in cooperation with other bodies in the United Nations system or other specialized agencies, including the Food and Agriculture Organization of the United Nations, the United Nations Environment Programme, the International Labour Organization, the OECD Nuclear Energy Agency, the Pan American Health Organization and the World Health Organization.

INTERPRETATION OF THE TEXT

Safety related terms are to be understood as defined in the IAEA Safety Glossary (see <http://www-ns.iaea.org/standards/safety-glossary.htm>). Otherwise, words are used with the spellings and meanings assigned to them in the latest edition of The Concise Oxford Dictionary. For Safety Guides, the English version of the text is the authoritative version.

The background and context of each standard in the IAEA Safety Standards Series and its objective, scope and structure are explained in Section 1, Introduction, of each publication.

Material for which there is no appropriate place in the body text (e.g. material that is subsidiary to or separate from the body text, is included in support of statements in the body text, or describes methods of calculation, procedures or limits and conditions) may be presented in appendices or annexes.

An appendix, if included, is considered to form an integral part of the safety standard. Material in an appendix has the same status as the body text, and the IAEA assumes authorship of it. Annexes and footnotes to the main text, if included, are used to provide practical examples or additional information or explanation. Annexes and footnotes are not integral parts of the main text. Annex material published by the IAEA is not necessarily issued under its authorship; material under other authorship may be presented in annexes to the safety standards. Extraneous material presented in annexes is excerpted and adapted as necessary to be generally useful.

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1. INTRODUCTION

BACKGROUND

1.1. Radioactive waste arises from the generation of electricity in nuclear power plants, from nuclear fuel cycle operations and from other activities in the nuclear fuel cycle, such as the mining and processing of uranium and thorium ores. Radioactive waste also arises from a wide range of activities in industry, medicine, agriculture, education, and research and development. It also arises from activities and processes in which radioactive material of natural origin becomes concentrated in waste material and safety needs to be considered in its management.

1.2. A monitoring and surveillance programme is a key element in verifying that a licensed radioactive waste disposal facility meets its specified performance and safety requirements. The safety principles to be applied in all radioactive waste management activities are established in the Fundamental Safety Principles [1]. The Safety Requirements publication on Disposal of Radioactive Waste [2] sets out disposal options corresponding to the recognized classes of radioactive waste as specified in Ref. [3].

1.3. The IAEA has developed Safety Guides on geological disposal facilities and on near surface disposal facilities [4, 5], and a Safety Guide on the management of radioactive residues from mining, mineral processing, and other activities relating to naturally occurring radioactive material (NORM) is in preparation. The present Safety Guide provides support for these safety standards in the area of monitoring and surveillance of radioactive waste disposal facilities.

1.4. Monitoring and surveillance programmes are important elements in providing assurance that a disposal facility for radioactive waste performs at the required level of safety during the operational and post-closure phases. The type of waste and the corresponding disposal facility will influence the monitoring approach taken. In the case of a near surface disposal facility, for waste containing relatively short lived radionuclides, it is possible to apply direct controls to determine whether the safety goals are being met. In the case of geological disposal of waste with long lived radionuclides, direct controls after closure are not feasible. The goals for safety and protection in this case can only be derived by predictions that are based on the available data and existing knowledge.

1.5. Differing kinds of monitoring activities are necessary in each period in the lifetime of a radioactive waste disposal facility. This Safety Guide covers monitoring and surveillance in the pre-operational, operational, closure and post-closure periods for specific landfill disposal facilities, near surface disposal facilities, geological disposal facilities and disposal facilities for waste from thorium and uranium mining. The pre-operational, operational and post-closure periods set out in Ref. [2] can be further described as follows:

- The pre-operational period includes concept definition, site evaluation (selection, verification and confirmation), safety assessment and design studies. In the case of waste from mining, the pre-operational period corresponds to preparation for environmental remediation of mining facilities, tailings management facilities, piles of waste rock and clean-up waste of the contaminated sites (remediation of mining waste can be looked upon as disposal of the mining waste). The pre-remediation activities include environmental impact assessment¹ of the sites surrounding the mine, selection and design of the remedial actions and implementation of an environmental monitoring programme that comprises monitoring of the impact of the remedial actions at the site and monitoring for any change in the environmental baseline conditions outside the remediation site. The pre-operational period also includes the development of programmes and procedures required in support of the application for a licence for construction and initial operation of a disposal facility. The monitoring and testing programmes that are needed to establish baseline conditions should be put in place during this period.
- The operational period begins when waste is first received at the facility. From this time, radiation exposures may occur as a result of waste management activities, and these are subject to control in accordance with the requirements for protection and safety. Safety assessments and the safety case for the period of operation are updated as necessary to reflect actual experience and increasing knowledge, gained both on the site and at other facilities, in the State and in other States. In the operational period, construction activities may take place at the same time as waste emplacement in and closure or decommissioning of other parts of the facility. This period may include activities for waste retrieval, if considered necessary, prior to closure, activities following the completion of waste

¹ The term ‘environmental impact assessment’ is used here in a broad sense. In some States, the term denotes a specified process covering all potential impacts of the project, with a view to soliciting acceptance of a project from all relevant authorities, and which often involves participation of the public.

emplacement and final closure, including backfilling and sealing of the facility. Records of the waste inventory should be kept throughout the operational period.

- Many reasons could lead to a decision to close a disposal facility. For example, the capacity of the disposal facility may have been reached; other solutions for disposal may have been found; or a political decision may have been made to close the facility. Irrespective of the rationale behind the decision, except in the case of remediation, a decision to close a disposal facility is also a decision to initiate a period of active institutional control, for a near surface disposal facility, or, for other disposal facilities, the post-closure period. Such a decision is specific to disposal facilities and is of high importance for near surface disposal facilities. Initiation of a period of active institutional control will lead to decisions on further activities following the completion of waste emplacement, namely closure and sealing of the disposal facility. At this time, the duration of this period of active institutional period should be determined in accordance with a ‘de minimis’ approach to the risks incurred by a potential human intruder.
- The post-closure period begins at the time when all the engineered containment and isolation features have been put in place, operational buildings and supporting services have been decommissioned, and the facility is in its final configuration. After its closure, the safety of the disposal facility is provided for by means of passive features inherent in the characteristics of the site and the facility and characteristics of the waste packages. A monitoring and surveillance programme is put in place aimed at confirming that the disposal system is performing as expected. Monitoring may also be carried out to enhance confidence in, and therefore acceptance of, the disposal process. For near surface disposal facilities in particular, institutional controls are put in place to prevent intrusion into the facility. Depending on national legislation, the licence to operate a disposal facility may be terminated after the period of active institutional control when all the necessary technical, legal and financial requirements have been fulfilled.

1.6. The IAEA’s General Safety Requirements publication Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards [6] and the IAEA Safety Guide on Environmental and Source Monitoring for Purposes of Radiation Protection [7] provide a framework for all generic aspects of monitoring. In particular, Ref. [6] establishes the basic requirements for monitoring of public exposure, while Ref. [7] covers pre-operational monitoring, operational monitoring and post-closure monitoring. It also acknowledges the need for monitoring a variety of non-radioactive variables. The present Safety

Guide provides recommendations on meeting the requirements in Ref. [6] and complements the guidance provided in Ref. [7], with particular regard to the role of monitoring in the context of the development of a disposal facility. On matters pertaining to source and environmental monitoring, the present Safety Guide refers to Ref. [7].

1.7. Reference [6] establishes requirements on the regulatory control and monitoring of public exposure and risks to the environment, as well as requirements on the safe management of radioactive waste.

1.8. Four IAEA publications address monitoring and surveillance of disposal facilities: Safety Reports Series No. 27 on Monitoring and Surveillance of Residues from the Mining and Milling of Uranium and Thorium [8]; Safety Reports Series No. 35 on Surveillance and Monitoring of Near Surface Disposal Facilities for Radioactive Waste [9]; Safety Reports Series No. 64 on Programmes and Systems for Source and Environmental Radiation Monitoring [10]; and IAEA-TECDOC-1208 on Monitoring of Geological Repositories for High Level Radioactive Waste [11]. The scope of the present Safety Guide is broader than that of these informational publications, which have served as a resource for development of this Safety Guide.

OBJECTIVE

1.9. The objective of this Safety Guide is to provide guidance for the monitoring and surveillance of radioactive waste disposal facilities throughout their entire lifetime. It addresses the different aims that monitoring and surveillance have at the various periods of the lifetime of a disposal facility, from initiation of work on a candidate site, to the period after closure of the disposal facility.

SCOPE

1.10. This Safety Guide considers monitoring and surveillance for three types of disposal facility:

- Near surface disposal facilities;
- Geological disposal facilities;
- Facilities for the disposal of waste from mining and mineral processing.

These three types of disposal facility cover all disposal options as identified in Ref. [2]. Specific landfill disposal facilities are not specifically mentioned as they involve the same considerations as near surface disposal facilities. Borehole disposal facilities also are not specifically addressed in this Safety Guide. However, borehole disposal involves many considerations similar to near surface disposal or geological disposal of radioactive waste. A possible surveillance and monitoring programme suitable for a small scale borehole disposal facility is described in Ref. [12].

1.11. The disposal of intermediate level waste in facilities, as described in Ref. [2], has to provide for long term, passive safety through a combination of natural and engineered barriers. The overall approach to monitoring in this case is similar to the monitoring system used for deep geological disposal. The similarities between the monitoring system for intermediate level waste (ILW) disposal and that for deep geological disposal are due to the fact that the waste is located at a considerable depth, and the monitoring system will reflect the combined long term effect of engineered barriers and the host rock formation.

1.12. As explained in Ref. [3], the term ‘near surface disposal’ generally refers to disposal at or within a few tens of metres from the surface of the ground. The term ‘geological disposal’ generally refers to disposal in deep, stable geological formations, usually several hundred metres or more below the surface. Disposal facilities for mining waste cover a spectrum of designs, from above ground mounds of waste to geological disposal of tailings slimes (a dispersion of fine tailings in water), which are sometimes used as backfill in old mines. The type of disposal required depends on the characteristics of the waste and the potential risk that the waste may pose to the environment [3]. The suitability of waste for disposal in a particular disposal facility is required to be demonstrated by the safety case and supporting safety assessment for the facility [2]. A dedicated monitoring and surveillance programme is part of this demonstration.

1.13. This Safety Guide emphasizes the integration of monitoring and surveillance activities necessary for development of and compliance with the safety case. The safety case includes information related to siting, construction, operation, closure and the period after closure that is necessary for supporting decisions on managing the disposal programme, as well as information that is of particular interest to interested parties such as local parties and the wider public [2, 13]. Technical details on monitoring and surveillance methodologies are beyond the scope of this Safety Guide; however, Refs [8–11] contain such information, and Annexes I and II provide examples of monitoring programmes for geological disposal programmes and for near surface disposal programmes.

1.14. Nuclear security aspects of the monitoring and surveillance of disposal facilities are outside the scope of this publication. Guidance on addressing nuclear security aspects can be found in publications of the IAEA Nuclear Security Series (see Refs [14, 15] and supporting guidance). The term ‘surveillance’ in this Safety Guide is used strictly with the meaning expressed in para. 2.7; therefore, this term is not to be understood as including surveillance for security purposes. Nevertheless, while designing surveillance programmes for security purposes, it may be taken into account that surveillance of disposal facilities for safety measures also can provide information relevant for security issues.

1.15. This Safety Guide focuses on monitoring for the purpose of confirming the performance of the disposal system and for radiation protection of the public and protection of the environment.

1.16. This Safety Guide does not specifically address monitoring that will be required for the following purposes:

- Occupational radiation protection (e.g. by means of dosimetry). This topic is covered in Ref. [16].
- Waste characterization or waste tracking.
- State systems of accounting for and control of nuclear material, or IAEA nuclear safeguards, for facilities that will contain significant quantities of nuclear material.
- Socioeconomic conditions (such as demographic changes, presence of industries, trade of goods, changes in social order).

This Safety Guide also does not provide recommendations on monitoring for non-radiological contaminants that may be of concern. However, the operator of the disposal facility should consider such contaminants when designing the monitoring programme.

STRUCTURE

1.17. Section 2 provides an overview of monitoring and surveillance for radioactive waste disposal facilities, and describes the overall objectives for a monitoring and surveillance programme. Section 3 addresses the roles and responsibilities of the regulatory body and the operator with regard to monitoring and surveillance. Section 4 addresses the design of a monitoring programme and includes some consideration of strategic issues for monitoring. Section 5 provides guidance on monitoring for different types of disposal facility

(geological disposal facilities, near surface disposal facilities and facilities for waste from mining and mineral processing). Section 6 addresses the monitoring that is necessary at different stages in the development of a disposal facility. Section 7 provides specific guidance for surveillance activities. Finally, Section 8 is concerned with the use of information from monitoring and surveillance with regard to aspects of compliance with regulations and the development and improvement of the safety case, and Section 9 describes briefly issues relating to the management system for a disposal facility. Annex I provides an example of monitoring and surveillance information collected for a geological disposal programme. Annex II describes a monitoring and surveillance programme for a near surface disposal facility, specifically the radioactive waste treatment and disposal facility at Püspökszilágy operated by the Hungarian national radioactive waste management company (PURAM).

2. OVERVIEW OF MONITORING AND SURVEILLANCE

2.1. Monitoring has been defined in various IAEA publications in different ways [6–11]. In the context of this Safety Guide, the term ‘monitoring’ refers to continuous or periodic observations and measurements to help evaluate the behaviour of the components of a waste disposal system and the impact of the waste disposal system on the public and the environment. Most specifically, it covers the measurement of radiological, environmental and engineering parameters.

2.2. The need to address public concern and expectations may also be considered in defining the monitoring programme.

2.3. As stated in para. 5.4 of Ref. [2], “Monitoring programmes have to be designed and implemented so as not to reduce the overall level of safety of the facility after closure”.

2.4. The monitoring programme should be designed in accordance with a graded approach. This means that the extent of the monitoring programme should be commensurate with the level of risk associated with the disposal facility.

2.5. The duration and frequency of monitoring should be in accordance with the timescale of natural variations in the processes and in the parameters being measured, as determined by regulatory requirements, and with changes in processes and parameters associated with construction and operation of the disposal facility.

2.6. The safety case is usually supported by data from a number of sources, including site specific measurements, regional data and generic information. Generally, site specific data are preferred. Where these are absent, relevant monitoring data may be available from other sources.

2.7. In the context of this Safety Guide, the term ‘surveillance’ refers to the physical inspection of a waste disposal facility in order to verify the integrity of the safety barriers.

2.8. Surveillance is employed periodically to verify through inspection that structures, systems and components continue to function as described in the safety case. In this respect the function of surveillance is to facilitate the detection of changes in the engineering structures and systems of the disposal facility that might affect the performance of the disposal system.

2.9. “A programme for the surveillance of the facility should be established and implemented as necessary and feasible. It should consist of planned activities carried out to verify that the facility is operating within the design limits and conditions and to detect any deterioration of structures, systems and components that could result in unsafe conditions” [17].

2.10. In some States there is no distinction between the concepts of monitoring and of surveillance for disposal facilities.

GENERAL OBJECTIVES FOR THE MONITORING AND SURVEILLANCE OF DISPOSAL FACILITIES

2.11. Monitoring is needed to evaluate any changes either in the actual performance of the facility or in processes or parameters that might influence the performance of the facility. Requirement 21 of Ref. [4] states:

“A programme of monitoring shall be carried out prior to, and during, the construction and operation of a disposal facility and after its closure, if this is part of the safety case. This programme shall be designed to collect and update information necessary for the purposes of protection and safety. Information shall be obtained to confirm the conditions necessary for the safety of workers and members of the public and protection of the environment during the period of operation of the facility. Monitoring shall also be carried out to confirm the absence of any conditions that could affect the safety of the facility after closure.”

2.12. In addition, Requirement 10 of Ref. [4] states:

“An appropriate level of surveillance and control shall be applied to protect and preserve the passive safety features, to the extent that this is necessary, so that they can fulfil the functions that they are assigned in the safety case for safety after closure.”

2.13. The monitoring and surveillance of disposal facilities for radioactive waste has five broad objectives:

- (i) To demonstrate compliance with regulatory requirements and with the licence conditions.
- (ii) To verify that the disposal system is performing as expected, as set out in the safety case. This means that the components of the disposal system are carrying out their functions as identified in the safety assessment.
- (iii) To verify that the key assumptions made and models used to assess safety are consistent with actual conditions.
- (iv) To establish a database of information on the disposal facility, the site and its surroundings. This database is used to support future decisions when proceeding from siting to construction, operation, closure and the period after closure. The database is also used to support decisions relating to updating concepts and procedures for monitoring.
- (v) To provide information for the public.

2.14. In general, the monitoring and surveillance programmes should be driven by, and should inform, the safety case. The results of the programmes should be used to strengthen the safety case and to build confidence in safety.

2.15. During the period between the decision to develop a waste disposal facility and closure of the facility, decisions will need to be made about how, when and whether to grant a licence and implement the various stages of the development of the disposal facility. One of the objectives of monitoring and surveillance, and of the analysis of the data, is to provide information to assist in making these decisions. Decision making is strongly influenced by societal and political considerations as well as by safety issues, and the process will be embedded in the national legal and regulatory system. The decision making process should be supported by an adequate organizational framework and corresponding technical and administrative measures.

2.16. The monitoring and surveillance programme should be used to confirm that the performance of the engineered and natural barriers is not compromised by operational activities.

2.17. In addition to its technical objectives, a monitoring and surveillance programme can be a suitable tool for enhancing public confidence. In that sense, consideration of public and societal interests and the concerns of interested parties may provide useful information to complement the monitoring programme.

2.18. Monitoring involves balancing the benefits of gains in information on the behaviour of certain components of the disposal facility against any detriment that might result from monitoring. A common feature of many investigations relating to the behaviour of the engineered barriers and the natural development of the environment around the disposal facility is that these measurements can affect the disposal system in an undesirable manner. In the operational period, when the waste is directly accessible, the benefits of monitoring need to be balanced against the additional radiation exposure of the operating personnel and the potential for conventional accidents to occur [18].

3. RESPONSIBILITIES OF THE OPERATOR AND THE REGULATORY BODY

RESPONSIBILITIES OF THE OPERATOR

3.1. The operator of the waste disposal facility should be responsible for carrying out the activities listed in para. 3.2. If a change in responsibilities occurs during operation or after closure of the facility, the new operator should also take measures to ensure that the monitoring and surveillance programmes continues, including in the period after closure, in a manner that meets national regulatory requirements and policies.

3.2. With regard to responsibilities relating to monitoring and surveillance, the operator:

- (a) Should design a monitoring and surveillance programme (including record keeping and archiving) that meets the requirements established by the regulatory body. The programme should be designed and refined throughout

the pre-operational, operational and post-closure periods of the facility, and should be customized appropriately to each of these periods.

- (b) Should perform adequate monitoring and surveillance in agreement with the regulatory body, as follows:
 - (i) Baseline monitoring before and during the construction stage and during pre-operational periods;
 - (ii) Timely detection of any abnormalities of system performance during the operational and post-closure periods.
- (c) Should develop contingency plans to address unexpected or abnormal system behaviour and should coordinate plans with responsible authorities involved in the event of a nuclear or radiological emergency, including off-site responders.
- (d) Should report periodically on the status of the monitoring and surveillance programme to the regulatory body; should provide evidence to the regulatory body that the waste disposal facility is appropriately monitored and controlled; and should report promptly on unexpected or hazardous circumstances, when detected, to the responsible regulatory body, organization or institution, specifying the place and time of occurrence.
- (e) Should retain, store, maintain and administer data acquired by means of monitoring and surveillance.
- (f) Should, during the time of concept definition in the pre-operational period, ensure that financial guarantees are in place for the monitoring and surveillance.

RESPONSIBILITIES OF THE REGULATORY BODY

3.3. The regulatory body should establish the necessary requirements for implementation of the monitoring and surveillance programme for the disposal facility and should be responsible for carrying out the activities listed in para. 3.4. The necessary guidance should be provided to the operator of the disposal facility, to enable monitoring and surveillance programmes to be established for all periods of the disposal process. The guidance should include recommendations on the duration of monitoring and surveillance in the post-closure period. The regulatory framework should ensure that an appropriate mechanism is established that will ensure the availability of adequate financial means for implementation of the monitoring and surveillance programme.

3.4. With regard to specific responsibilities relating to monitoring and surveillance, the regulatory body:

- (a) Should periodically review the regulations in force for monitoring and surveillance, the monitoring and surveillance programmes and reporting arrangements, including arrangements for monitoring in an emergency. The times at which reviews are conducted should be sufficiently flexible to allow for changes arising from scientific and technological advancements in the relevant fields and from the needs of the regulatory body.
- (b) Should review the monitoring and surveillance data provided by the operator against established requirements.
- (c) Should verify that the waste disposal facility is being appropriately monitored and controlled by the operator; this may include the independent conduct of monitoring and surveillance. To some extent, and without prejudice to its independence, the monitoring programme of the regulatory body will need to be consistent and compatible with the monitoring strategy of the operator regarding safety aspects (both long term safety and operational safety) and practical considerations relating to management of the disposal process (including dismantling of the monitoring instrumentation).
- (d) Should ensure that financial guarantees are in place in the pre-operational period for long term monitoring and surveillance.

3.5. Specific tasks relevant to source and environmental monitoring as well as surveillance may be delegated to other organizations by the government or by the regulatory body using a transparent and auditable process that is subject to independent scrutiny. In deciding on the delegation of specific tasks to other organizations, the regulatory body should give due consideration to the availability of suitably qualified and experienced personnel, appropriate analytical techniques and equipment, and an appropriate management system. Examples of tasks that may be delegated are the following:

- (a) The design and implementation of source and environmental monitoring programmes, such as programmes conducted to assess the cumulative radiological impact of multiple or related facilities on the same areas and the same population groups;
- (b) The assessment of doses to members of the public, to verify that they are maintained below the limits established in the licence;
- (c) Tasks relating to safety and emergency response.

3.6. Other organizations may also be made responsible for other domains relating to monitoring, such as:

- (a) The collection and retention of data provided by the operator, governmental agencies or international agencies;
- (b) Environmental monitoring at the national level;
- (c) The establishment of standards.

The regulatory body should liaise with these organizations as appropriate.

3.7. Provision should be made for rapid, large scale monitoring in the event of an accident. Such monitoring may be performed by a designated organization with the requisite capability, or by the regulatory body itself. The required monitoring may include source monitoring (monitoring at the source of the discharge), environmental monitoring (monitoring in the vicinity of the facility) and individual monitoring (monitoring of individual exposure) [7].

4. DESIGN OF A MONITORING PROGRAMME

4.1. The monitoring programme for a disposal facility should be designed to meet the objectives stated in Section 2. It should include source and environmental monitoring programmes to assess public exposure and impact on the environment as well as to assess potential release pathways. Generic aspects of source and environmental monitoring for waste disposal facilities are described in Ref. [7]. The monitoring programme should include assessment of the performance of the disposal system for the operational and post-closure periods.

4.2. The safety case should be used to establish the monitoring programme for confirmation of the performance of the disposal facility. The responses of the disposal system should be monitored and the results should be compared to predictions made in the safety assessment in order to demonstrate the quality of the site characterization data and to confirm the assumptions made and the models used in the safety case.

4.3. Data from the monitoring programme should be analysed promptly to provide the operator and decision makers with timely information on management of the disposal facility. In particular, the regulatory body should be provided with a summary of monitoring results and their interpretation at defined intervals