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Decommissioning of Nuclear Fuel Cycle Facilities

SAFETY GUIDE

No. WS-G-2.4

INTERNATIONAL
ATOMIC ENERGY AGENCY
VIENNA

DECOMMISSIONING OF NUCLEAR FUEL CYCLE 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''.

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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 for 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.

CONTENTS

1. INTRODUCTION

BACKGROUND

1.1. This Safety Guide is issued under the IAEA Radioactive Waste Safety Standards Programme, which addresses all the important areas of radioactive waste safety. This series includes Safety Fundamentals [1], Safety Requirements and Safety Guides in the IAEA Safety Standards Series.

1.2. Safety requirements for decommissioning are set out in the Safety Requirements publication Predisposal Management of Radioactive Waste, Including Decommissioning [2]. Other IAEA safety standards provide additional relevant safety requirements [3]. A Safety Requirements publication, Legal and Governmental Infrastructure for Nuclear, Radiation, Radioactive Waste and Transport Safety, establishes specific requirements for legal and governmental infrastructures to support decommissioning activities [4].

1.3. Decommissioning is the final stage in the life cycle of a nuclear facility. With the maturing of the nuclear industry, many facilities are approaching decommissioning. Safety management, as demonstrated in the proper planning and implementation of decommissioning, provides for the protection of the health of workers and the public and of the environment.

1.4. This Safety Guide sets out recommendations relating to the decommissioning of nuclear fuel cycle facilities. It includes guidance on selecting the appropriate decommissioning option for the facility concerned, identifies critical tasks and key issues, and discusses methods for managing the decommissioning activities. The guidance is derived from the basic principles for radioactive waste management set out in The Principles of Radioactive Waste Management [1] and the Safety Requirements publication Predisposal Management of Radioactive Waste, Including Decommissioning [2].

1.5. Two other Safety Guides are concerned with the decommissioning of nuclear power plants and research reactors, and the decommissioning of medical, industrial and research facilities [5, 6].

OBJECTIVE

1.6. The objective of this Safety Guide is to provide guidance to regulatory bodies and operating organizations on planning and provision for the safe management of the

decommissioning of non-reactor nuclear fuel cycle facilities. While the basic safety considerations for the decommissioning of nuclear fuel cycle facilities are similar to those for nuclear power plants, there are important differences, notably in the design and operating parameters for the facilities, the types of radioactive material and the support systems available. It is the objective of this Safety Guide to provide guidance for the shutdown and eventual decommissioning of such facilities, their individual characteristics being taken into account.

SCOPE

1.7. This Safety Guide addresses the safe decommissioning of nuclear fuel cycle facilities, such as:

(a) Surface processing facilities for mining and milling of uranium and thorium,
(b) Uranium conversion facilities,
(c) Uranium enrichment facilities,
(d) Fuel fabrication facilities,
(e) Spent fuel storage facilities away from the reactor,
(f) Reprocessing facilities,
(g) Storage facilities for radioactive waste,
(h) Treatment and conditioning facilities for radioactive waste.

1.8. Although analytical laboratories, research facilities and laundries are often located on the same sites as nuclear fuel cycle facilities, decommissioning of most facilities of these types is addressed not in the present publication but in another IAEA Safety Guide [6]. However, for complex research facilities where decommissioning would involve decontamination and dismantling activities on a larger or more complex scale, the guidance in the present Safety Guide may be applicable.

1.9. Disposal of associated radioactive waste and closure of waste repositories are not addressed in this Safety Guide but are considered in another publication [7]. The management of mining and milling residues, such as tailings and waste rock, is also outside the scope of this publication. However, the decommissioning of facilities and equipment for surface industrial extraction associated with mining and milling is covered.

1.10. This Safety Guide addresses mainly the radiological hazards resulting from the activities associated with the decommissioning of fuel cycle facilities, primarily with decommissioning after a planned shutdown. Many of the provisions are also applicable to decommissioning after an abnormal event that has resulted in serious system

damage or contamination. In this case, this publication may be used as a basis for developing special decommissioning provisions, although additional considerations will also be necessary.

1.11. Non-radiological hazards, such as those due to potential fire sources or those resulting from the release of asbestos, can also arise during decommissioning activities. This Safety Guide does not explicitly address these hazards, but they should be given due consideration during the planning process and in the risk analysis.

STRUCTURE

1.12. Key issues in the decommissioning of nuclear fuel cycle facilities are addressed in Section 2. The process for selecting the proper decommissioning option is discussed in Section 3. Considerations in facilitating the decommissioning of nuclear fuel cycle facilities are explained in Section 4. Planning and performing a safety assessment for decommissioning of a nuclear fuel cycle facility is the subject of Section 5. Tasks that are critical to decommissioning because of their complexity and/or their relevance to key safety issues are discussed in Section 6. The overall management of the decommissioning process is described in Section 7. Completion of decommissioning and the contents of the final decommissioning report are addressed in Section 8.

1.13. An Annex provides an example of the contents of a final radiological survey report.

2. KEY ISSUES SPECIFIC TO DECOMMISSIONING

GENERAL

2.1. The term ‘decommissioning’ refers to administrative and technical actions taken to allow the removal of some or all of the regulatory controls from a nuclear facility (except for a repository which is ‘closed’ ratter than ‘decommissioned’). These actions involve decontamination, dismantling and removal of radioactive materials, waste, components and structures. They are carried out to achieve a progressive and systematic reduction in radiological hazards and are undertaken on the basis of preplanning and assessment, in order to ensure safety during decommissioning operations.

2.2. The time period necessary to achieve decommissioning will depend on the type of installation, the radionuclide inventory, the chosen decommissioning strategy, the techniques employed and, in certain cases, the policy for waste management. The timing of decommissioning shall be such that it does "not impose undue burdens on future generations" in terms of both additional health and safety risks and financial requirements (Ref. [1], principle 5). In the case of fuel cycle facilities which contain long lived alpha contamination, this may mean that early dismantling will be the preferred option.

2.3. Decommissioning may include the phased release of parts of the nuclear fuel cycle facility or parts of the site from regulatory control before the decommissioning process for the entire installation or the entire site is complete. In the event that a part of the installation is being decommissioned, this Safety Guide applies only to the decommissioning activities. However, the potential safety implications with regard to the interaction between any decommissioning work and continuing facility operations should be addressed on a case by case basis.

2.4. Subject to national legal and regulatory requirements [4], a nuclear facility or its remaining parts may also be considered to be decommissioned if they are incorporated into an existing or new facility which is, or will be, under regulatory control. This could apply where the facility to be decommissioned is located on a site with other nuclear facilities, including where the site remains under regulatory or other institutional control. In this case, the dismantling of the remaining facilities should be included in decommissioning planning for the entire site.

2.5. There are many factors that should be addressed to ensure the safety of nuclear fuel cycle facilities during the operational phase. Some of the factors may continue to apply during decommissioning, but decommissioning itself gives rise to issues which are different from those prevailing during the operation of the installation. These issues, which are identified later in this Safety Guide, should be considered in an appropriate way to ensure the overall safety of decommissioning.

RESPONSIBILITIES

2.6. When a nuclear fuel cycle facility is taken out of service, the licence may be reissued, modified or transferred to a different organization which becomes the new operating organization of the installation for the decommissioning phase. Decommissioning activities may involve many additional organizations, including contractors and subcontractors who may not be familiar with nuclear facilities. Responsibilities and interfaces between the different organizations should be properly defined by the

operating organization (licensee). The operating organization (licensee) shall have the ultimate responsibility for safety during the decommissioning operations, even when contractors are used to perform specific tasks or functions (Ref. [2], paras 3.11 and 3.16).

2.7. Responsibilities of organizations involved in the generation and management of radioactive waste, including responsibilities for the safe decommissioning of nuclear fuel cycle facilities, and the specific responsibilities of organizations involved in the decommissioning of nuclear fuel cycle facilities are established in Ref. [4].

2.8. The operating organization shall develop and safely implement the decommissioning plan (Ref. [2], para. 3.13) and shall begin planning for decommissioning in the design and construction stage and continue this during operation (Ref. [2], para. 6.2). The operating organization also:

(a) Should retain the necessary resources, expertise and knowledge for decommissioning and should keep records and documentation relevant to the design, construction, operation and decommissioning processes so that such information can be transferred to any supporting or successor operating organization;
(b) Should ensure maintenance of records and documentation for a period of time as specified by the regulatory body following the completion of decommissioning, including key information such as the results of the final radiological survey;
(c) Should report to the regulatory body on a scheduled basis any safety related information as required by the terms of the licence.

2.9. The operating organization should develop a public information programme to provide information about the decommissioning project.

REGULATORY FRAMEWORK

2.10. As decommissioning activities have become more frequent, there has been a trend in many countries to develop national regulations or specific guidance. The regulatory framework of a country shall include requirements for the decommissioning of nuclear fuel cycle facilities (Ref. [2], para. 3.4). In the absence of specific regulatory requirements, decommissioning activities could be undertaken on a case by case basis under existing regulations for operational facilities. In such cases, more frequent consultation between the operating organization and the regulatory body should be considered.

2.11. The regulatory control of decommissioning can be accomplished by a single overall licence, separate licences or direct supervision by a regulatory body. It should

be considered which arrangement is the most appropriate under the circumstances. In some cases, it may be helpful to approve the decommissioning plan by issuing a new licence or amending the existing licence, or to control the detailed decommissioning work through a local presence of the regulatory body.

2.12. The regulatory body shall develop the regulations or guidance necessary to put into effect the decommissioning policy and strategy (Ref. [2], para. 3.7), including the establishment of radiological criteria for the removal of materials, buildings and sites from regulatory control, and to ensure that adequate systems are in place for properly managing the removal of controls (Ref. [2], para. 3.8). The regulatory body also:

(a) Should review the selected decommissioning option, decommissioning plans, quality assurance programmes and other submissions relating to the performance of decommissioning of a nuclear installation in terms of radiological, nuclear and conventional safety;
(b) Should liaise with other regulatory bodies which have responsibilities for non-radiological hazards.

SAFETY

2.13. In all phases of decommissioning, workers, the public and the environment shall be properly protected from both radiological and non-radiological hazards resulting from the decommissioning activities (Ref. [2], para. 2.2). The operating organization (licensee) should prepare a detailed assessment of those hazards, including an accident analysis where necessary. Section 5 of this Safety Guide outlines the contents of a safety assessment. The assessment should identify protective measures which may be different from those in place during the operation of the facility.

2.14. Decommissioning of nuclear facilities often involves the removal, at an early stage, of large quantities of radioactive material, including the residual process material and the operational waste. Even after this step, the total amount of contamination remaining within the facility may still be significant and should be taken into account in the safety assessment.

2.15. The implementation of particular activities such as decontamination, cutting and handling of large components and the progressive dismantling or removal of some existing safety systems should be given careful consideration with regard to the safety of workers. These activities have the potential for creating new hazards. The

safety aspects of these activities should be adequately assessed and managed in decommissioning so as to mitigate any potential exposure.

2.16. Special safety issues that should be considered in the decommissioning of nuclear fuel cycle facilities may include:

(a) The presence and nature of all types of radioactive contamination and, in particular, alpha contamination;
(b) The significantly higher radiation levels in some facilities, necessitating the consideration of remote handling;
(c) The increased hazards associated with the possible in-growth of radionuclides (such as americium);
(d) The potential in some facilities for criticality hazards associated with the possible accumulation of fissile material during activities for decontamination or dismantling;
(e) The complexity of strategies for waste management owing to the diversity of waste streams;
(f) The hazards, such as fire or explosion, associated with the original chemical processing activities.

CONSIDERATIONS FOR RADIATION PROTECTION AND ENVIRONMENTAL PROTECTION

2.17. Consideration should be given to the protection of both workers and members of the public from exposure, not only during decommissioning but also as a result of any subsequent occupancy or use of the decommissioned site. “National radiation protection requirements shall be established with due regard for the International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources (BSS) [3]” (Ref. [2], para. 2.4).

2.18. During decommissioning of nuclear fuel cycle facilities, radioactive and non-radioactive pollutants may be released to the environment. These releases shall be controlled in compliance with appropriate national regulations (Ref. [3], para. III.3). Guidance on the regulatory control of the release of radioactive effluents to the environment has also been issued in IAEA safety standards [8].

2.19. Guidance on radiological criteria for the removal of regulatory control from materials, equipment and sites is being developed in other IAEA Safety Standards Series publications.

2.20. Decommissioning of nuclear fuel cycle facilities invariably involves the generation of radioactive waste. In the course of the decommissioning, waste is generated in forms that are not typical of the types of materials and waste routinely handled during the operational phase of the facility. Appropriate techniques for decontamination and dismantling should be applied and materials should be reused or recycled in order to minimize the amount of radioactive waste to be managed. It should be ensured that systems and facilities are available for managing the waste generated during decommissioning, including storage and/or disposal facilities.

3. SELECTION OF A DECOMMISSIONING OPTION

3.1. A specific decommissioning option will, among other capabilities, define the timing and the sequencing of decommissioning activities. The selected option should be justified by developing the decommissioning plan in compliance with the safety requirements specified by the regulatory body. There are three primary decommissioning options that should be considered in planning a decommissioning project for a nuclear fuel cycle facility: immediate dismantling, deferred dismantling and entombment. Other options that may be considered are combinations or variations of these three options. An evaluation of the various decommissioning options should be performed by considering a wide range of issues such as those that are identified in para. 3.3, with special emphasis on the constraints imposed by the safety requirements and the resources available at the time of decommissioning.

3.2. The specific characteristics of each type of nuclear fuel cycle facility will strongly influence the selection of the decommissioning option. Furthermore, non-safety related matters should also be considered (such as recycling of material as opposed to disposal) in the process of selecting an option. Where relevant, safeguards related issues should also be considered in optimizing both safety and resources in the decision making process for the optimal decommissioning strategy. The diversity of types of nuclear fuel cycle facilities makes characterization of the site and facility a critical step in the process of selecting a decommissioning option because the characterization defines the scope of the proposed project.

3.3. The following issues should be considered in selecting an option for decommissioning a nuclear fuel cycle facility:

(a) The status of laws, regulations and standards to be applied during decommissioning;
(b) The radiological criteria used as a basis for the removal of material from regulatory control;
(c) The types of processes used during the operational period (solvent extraction, ion exchange, chemical leaching);
(d) The size, configuration and condition of the facility;
(e) The availability and reliability of information on the design and operational history of the facility;
(f) The diversity of structures, systems and components used in the operational phase (incinerators, evaporators, powder mixers, gloveboxes, hot cells), as well as their accessibility;
(g) The types of radiological and non-radiological hazards;
(h) The types, levels and amounts of radionuclides present;
(i) Any releases or spills that may influence decommissioning;
(j) The views of the regulatory body on the particular decommissioning activity;
(k) The potential for inadvertent criticality;
(l) Any ancillary support features (ponds, lay-down areas);
(m) The availability of appropriate techniques and technologies for decontamination and dismantling;
(n) The availability of suitably trained staff, with appropriate safety related skills and experience;
(o) The potential for using existing structures, systems and components of the facility in the decommissioning activities (ventilation, waste treatment, cranes, barriers);
(p) The availability of options for waste disposal or waste storage and for means of transportation;
(q) The ability to assay and characterize waste;
(r) The adequacy and availability of financial resources;
(s) The potential impact on other facilities, unrelated activities and the public in the surrounding area;
(t) Any time constraints on decommissioning;
(u) The public's views and concerns;
(v) The possible use of the buildings and the site for other purposes.

3.4. With regard to the management of waste generated, if no suitable disposal sites have been identified, the following options for decommissioning should be evaluated in the preparation of the decommissioning plan:

(a) Optimizing the treatment and conditioning strategies (reducing the hazard and/or the volume of waste);
(b) Dismantling the facility and storing the waste that is generated at an interim waste storage facility;
(c) Deferred dismantling;
(d) Disposing of the facility in situ (entombment) and requiring the conversion and relicensing of the facility as a radioactive waste repository.

3.5. The selection of the preferred option for decommissioning should be based on consideration of the issues identified in para. 3.3. Cost–benefit or multi-attribute type analysis provides a systematic means for such evaluation. This analysis should use realistic estimates of both costs and radiation doses. The costs of maintenance, surveillance and physical protection for the nuclear facility should also be taken into account, particularly if deferred dismantling is being considered. It shall be ensured that the selected option meets all the applicable safety requirements (Ref. [1], principle 9).

3.6. Deferral of decommissioning activities may not significantly reduce the activity of the remaining radionuclides, the quantities of radioactive waste produced or radiation exposure of site personnel. This is due to the relatively long half-lives of the radionuclides involved and, in some cases (such as americium), the potential for isotopic in-growth. Additional disadvantages in delaying the decommissioning activities include the gradual deterioration of structures, systems and components designed to act as barriers between the inventory of radionuclides and the environment, and the loss of the operating personnel's experience. The deterioration may also apply to systems that could be used during dismantling of the facility. In implementing deferred dismantling, it should be considered whether new structures and systems should be installed or whether existing structures and systems should be modified. The integrity of any new structures and systems should be assessed over the period of surveillance and maintenance.

3.7. In most cases, entombment is not considered a reasonable option for the decommissioning of nuclear fuel cycle facilities that are contaminated with long lived alpha radionuclides. Entombment implies that most of the radioactive material will be permanently emplaced in an engineered structure near the surface. The IAEA has recommended that waste which contains significant amounts of such radionuclides should not be disposed of in near surface facilities [7, 9].

4. FACILITATING DECOMMISSIONING

INTRODUCTION

4.1. The requirements for decommissioning shall be considered at the design stage for a new facility (Ref. [2], para. 6.2) or should be considered as soon as possible for existing facilities. The later in the facility's lifetime that consideration is given to facilitating decommissioning, the more difficult and costly the decommissioning may become. This may be due to the lack of adequate records and information, the need to install or modify equipment or the increased complexity of decommissioning activities. It may also be because of the necessity of incurring additional doses as a result of aspects of the design that complicate decommissioning activities.

CONSIDERATIONS AT THE DESIGN AND CONSTRUCTION PHASE

4.2. Decommissioning shall be considered in the design, construction and operational phases (Ref. [2], para. 6.2). However, many nuclear fuel cycle facilities have been operating for many years and decommissioning may not have been considered at the design stage. This should be recognized in the planning of decommissioning for such facilities and preparations should start as early as possible. For such facilities, modifications to buildings and systems should incorporate features that would facilitate decommissioning, enhance radiation protection and minimize environmental impacts.

4.3. Design features that should be considered in order to facilitate decommissioning include:

(a) Remote maintenance and monitoring capabilities;
(b) Compartmentalization of process functions;
(c) Protective coverings and liners in process cells and areas where liquids may be present;
(d) Limited reliance on storage of highly radioactive waste liquids;
(e) Ready access to process equipment, structures, systems and components;
(f) Ease of removal and/or decontamination of material or equipment;
(g) Built-in decontamination mechanisms;
(h) Possible processes for reducing the volumes of waste;
(i) Configuration, sizing and layout of process equipment;
(j) Retrievability of operational waste or temporarily stored waste;
(k) Lifting and handling equipment;

(l) Ventilation and effluent systems;
(m) Modular construction in order to facilitate the dismantling of structures, systems, equipment and components not subject to ready decontamination (such as that for easily separated mechanical and electrical components).

4.4. For new fuel cycle facilities, a 'baseline' background radiological characterization of the site and the facility itself should be undertaken. This should include appropriate radiological monitoring of the site for the proposed facility and the surrounding area to establish baseline levels of radiation for use in assessing the future impact of the facility on the site. This may be critical to future decisions on the acceptability of decommissioning proposals. Quantification of the natural activity in building materials used for construction may prove useful in determining future clearance levels and target cleanup levels in the facility during decommissioning.

CONSIDERATIONS DURING FACILITY OPERATION

4.5. Decommissioning can be facilitated by planning and preparatory work undertaken during the entire lifetime of the facility. This work should be aimed at minimizing the eventual occupational and environmental impacts from decommissioning activities.

4.6. As an important factor in facilitating decommissioning, as-built drawings and institutional knowledge from the operational period of the facility should be retained. The degree of success in retaining experienced personnel and records from the operational period will directly influence the progress of decommissioning. Deferral of decommissioning will increase the potential for loss of key personnel and information.

5. PLANNING AND SAFETY ASSESSMENT FOR DECOMMISSIONING

GENERAL

5.1. Successful decommissioning depends on careful and organized planning. "A decommissioning plan shall be developed for each nuclear facility, unless otherwise required by the regulatory body" (Ref. [2], para. 6.2). The extent of the plan, its content and the degree of detail necessary may vary depending on the complexity and

hazard potential of the nuclear facility, and they should be consistent with national regulations.

5.2. The operating organization shall plan for adequate financial resources to ensure the decommissioning of the facility (Ref. [2], para. 3.17). Especially in the case of deferred dismantling, where there may be long safe enclosure periods, these financial provisions should be reviewed periodically and adjusted as necessary to allow for inflation and other factors such as technological advances, waste costs and regulatory changes. Responsibility for this review may reside with the operating organization, the regulatory body or other parties, depending on the national legal framework.

5.3. A safety assessment should form an integral part of the decommissioning plan. The operating organization is responsible for preparing the safety assessment and submitting it for review by the regulatory body (Ref. [2], para. 7.3). The safety assessment should be commensurate with the complexity and potential hazard of the facility and, in the case of deferred decommissioning, should take into account the safety of the facility during the period leading up to final dismantling.

5.4. The three stages of planning are envisaged as initial, ongoing and final. For a given facility, the degree of detail will increase from the initial to the final decommissioning plan. This planning process will result in the production of the decommissioning plan.

5.5. Records from the siting, design, construction, operation and shutdown are essential to the planning of decommissioning. Although such records need not be explicitly included in the decommissioning plan itself, the process of initial, ongoing and final planning should use pertinent records to achieve safety and optimize efficiency in decommissioning.

INITIAL PLANNING

5.6. An initial plan for decommissioning shall be prepared which outlines the overall decommissioning process (Ref. [2], para. 3.13). This plan should be submitted by the operating organization to the regulatory body in support of the licence application for commissioning and/or operating the facility. This plan:

(a) Should take into account basic safety issues;
(b) Should support the fact that decommissioning can be safely conducted using proven techniques or ones being developed;
(c) Should include a generic study showing the feasibility of decommissioning;

(d) Should include consideration of environmental aspects of decommissioning, such as management of waste and radioactive effluents;
(e) Should address the costs of the decommissioning work and the means of financing it.

5.7. The existing facilities and equipment that will be used during decommissioning should be identified at an early stage in the initial planning phase. This will enable the necessary steps to be taken to ensure that the equipment is available when needed.

5.8. If the facility is collocated with other facilities that will not be decommissioned at the same time, the interfaces between these facilities should be analysed. In many cases, support systems (waste processing, raw water, ventilation) may support all of the on-site facilities and may be routed through the facility that will be decommissioned. This would complicate the planning owing to the possible need to reroute these systems.

ONGOING PLANNING

5.9. During the operation of a nuclear fuel cycle facility, the initial decommissioning plan shall be periodically reviewed and updated (Ref. [2], para. 6.3), and should be made more comprehensive with respect to:

(a) Technological developments in decommissioning,
(b) Possible abnormal events,
(c) Significant modifications to systems and structures affecting the decommissioning plan,
(d) Amendments to regulations and changes in government policy,
(e) Cost estimates and financial provisions.

FINAL PLANNING

5.10. Before the final shutdown of a facility, the operating organization should initiate detailed studies and finalize proposals for decommissioning. The operating organization shall submit an application together with the proposed final decommissioning plan for review and approval by the regulatory body (Ref. [2], para. 6.5).

5.11. As decommissioning is undertaken, there may be modifications to the decommissioning programme owing to unexpected events and other factors. These may necessitate changes to the decommissioning plan which should be incorporated in a systematic way. These changes may require further approval by the regulatory body.

5.12. The final decommissioning plan should include, where applicable, the following items:

(a) A description of the nuclear fuel cycle facility, the site and the surrounding area that could affect, and be affected by, its decommissioning;
(b) The life history of the facility, reasons for taking it out of service, and the planned use of the site during and after decommissioning;
(c) Information on incidents that have occurred during the operational phase, in particular those involving spills and the release of radioactive material;
(d) Details of significant modifications carried out during the operational phase;
(e) An assessment of the amount, type and location of residual radioactive and hazardous non-radioactive materials in the facility, including calculational methods and measurements to determine the inventories (i.e. the characterization of the facility);
(f) A description of the regulatory framework within which decommissioning will be carried out;
(g) A description of the proposed decommissioning activities, and the programme, including a detailed schedule;
(h) The rationale for selecting the preferred decommissioning option;
(i) Descriptions of safety assessments and environmental impact assessments, including the potential radiological and non-radiological hazards to the workers, the public and the environment;
(j) A description of the proposed environmental monitoring programme to be undertaken during decommissioning;
(k) A description of the experience, resources and responsibilities of the decommissioning organization, including details of the qualifications, skills and training of the decommissioning personnel;
(l) A statement of the availability of any specific management, engineering and decommissioning techniques;
(m) A description of the proposed strategy for waste management;
(n) A description of the proposed programmes for radiation protection and safety to be used during decommissioning;
(o) A description of the criticality control programme, if necessary;
(p) A description of the quality assurance programme;
(q) A description of the measurement programme, equipment and methods to be used to verify that the site will comply with the release requirements;
(r) A demonstration of the adequacy of the financial mechanism for ensuring that decommissioning, including waste management, will be carried out in a safe manner;
(s) A description of the organizational and administrative controls;

(t) A description of other applicable important technical and administrative considerations such as safeguards, physical protection arrangements and details of emergency preparedness.

SAFETY ASSESSMENT FOR DECOMMISSIONING

5.13. A safety assessment forms an integral part of the decommissioning plan. The operating organization is responsible for preparing the safety assessment and submitting it to the regulatory body for review. The extent and detail of the safety assessment "shall be commensurate with the complexity and the hazard associated with the facility or operation" (Ref. [2], para. 7.4).

5.14. Non-radiological as well as radiological hazards associated with the decommissioning activities should be identified and evaluated in the safety assessment. As a result of this assessment, the protective measures can be defined that will ensure that the regulatory requirements are met. These protective measures may require changes to the existing safety systems that were used during operation. The acceptability of such changes should be clearly justified in the safety assessment. In addition, the requirements for maintenance or replacement of systems for mechanical handling, ventilation, power supply and waste handling should be considered in the safety assessment, and the implications for reduced safety due to the deterioration of systems should be evaluated.

5.15. Early in the planning stage for decommissioning, the degree and extent of contamination should be clearly determined, characterized, evaluated and classified. Surveys should be conducted to determine the inventories and locations of radioactive, fissile and other hazardous materials. An accurate characterization of the facility will provide the input for the safety assessment and the criticality analysis (paras 6.1–6.4).

Safety with regard to non-radiological hazards

5.16. The safety assessment may identify a number of potentially significant non-radiological hazards during the decommissioning phase which might not have been normally encountered during the operational phase. These may include the lifting and handling of heavy loads, and the use of hazardous materials during the activities for decontamination, dismantling and demolition. Although the method for dealing with most of the non-radiological hazards should be managed according to national regulations, a strong safety culture will help to ensure that such hazards are identified and adequately controlled.

General results of the safety assessment

5.17. The safety assessment should lead to the determination of actions that are necessary for ensuring safety during the various phases of decommissioning. Such actions may be protective measures which are engineered or administratively controlled to provide the necessary defence in depth. The elements of defence in depth will vary and evolve as progress is made in the decommissioning of the facility.

Release from regulatory control

5.18. The radiological criteria for the release of the facility and site from regulatory control may be defined in a generic way or may be derived specifically by the competent authorities. As a result of the safety assessment, the actions that should be taken to satisfy the regulatory criteria will be determined for inclusion in the decommissioning plan.

FINANCIAL ASSURANCE FOR DECOMMISSIONING

5.19. The cost of decommissioning should reflect all activities described in the decommissioning plan, for example, planning and engineering during the post-operational phases, the development of a specific technology, decontamination and dismantling, conducting the final survey and the management of waste. The cost of maintenance, personnel qualification, surveillance and physical protection of the facility should be taken into account, especially if any phase of decommissioning is deferred for an extended period of time.

5.20. In order to provide the necessary confidence that the resources will be available to maintain radiation and environmental protection during decommissioning, provision for allocating resources should be established early in the planning of the facility. According to the legal framework, such a mechanism should be established prior to operation to secure the funds needed for decommissioning. The mechanism should be sufficiently robust to provide for decommissioning needs in the event of a premature shutdown of the facility. Irrespective of the type of financial mechanism used, provision for premature decommissioning should be in place should it be needed.

5.21. For existing fuel cycle facilities that do not have a financial assurance mechanism for decommissioning, such a mechanism should be established without undue delay.

6. CRITICAL DECOMMISSIONING TASKS

CHARACTERIZATION OF THE FACILITY

6.1. A survey of radiological and non-radiological hazards should be made as an important input to the safety assessment for decommissioning and for implementing a safe approach during the work. The survey should be conducted to identify the inventory and location of radioactive materials and other hazardous materials. In planning and implementing surveys, use should be made of existing records and operating experience. A characterization report should be prepared which documents the information and data obtained during the characterization process.

6.2. An adequate number of radiation and contamination surveys should be conducted to determine the radionuclides, maximum and average dose rates, and contamination levels for inner and outer surfaces throughout the facility. For completeness, contamination in shielded or self-shielded components, such as inside pipes and equipment, should be characterized. Results of such surveys will assist in the preparation of radiation and contamination maps. Some of these results and maps may be available from audits performed during the facility's operational period. Furthermore, special surveys to determine the penetration depth and extent of contamination may be necessary to assist in the selection of appropriate procedures.

6.3. An inventory of all hazardous chemicals present in the facility should be conducted. Hazardous materials such as asbestos, mercury and polychlorinated biphenyls (PCBs) require special consideration to prevent harm to human health and to the environment. Consideration should also be given to the compatibility of chemicals which are present or which may be introduced during decommissioning. For facilities which have been inoperable for a long period of time before decontamination or dismantling begins, a survey of equipment and buildings should be made to assess hazards associated with the deterioration of structures and systems.

6.4. Special attention should be paid during the characterization of any fissile material that may be left in the plant. Uncertainty about the amounts of fissile material could have severe consequences if assessments for criticality are incomplete or wrong.

REMOVAL OF THE RESIDUAL PROCESS MATERIAL

6.5. Significant amounts of residual process material may be present in both planned and unplanned locations at the time of shutdown. This material, which may

consist of spent nuclear fuel, new fuel, enriched uranium, plutonium or high activity waste, can give rise to hazards when disturbed by decommissioning operations. The removal of this material can be considered part of the shutdown of the facility or part of decommissioning. In either case, appropriate information on the disposition of the material should be provided.

6.6. Even when the bulk of the residual process material has been removed, a significant amount of radioactive contamination may remain. The expeditious removal of the residual process material, which would be beneficial and would reduce requirements for monitoring and surveillance, should be considered. Other activities associated with decommissioning may be conducted concurrently with the removal of residual process material, but potential interactions should be identified and assessed.

DECONTAMINATION

6.7. Decontamination covers a broad range of activities directed towards the removal or reduction of radioactive contamination in or on materials, structures and equipment. Dismantling may be aided at certain stages through the reduction in the need for radiological controls by means of the partial or total decontamination of the structures or systems necessary to be dismantled. The objectives of decontamination include:

(a) Reduction of potential on-site and off-site radiological hazards associated with further decommissioning activities;
(b) Reduction of exposure to permit manual or semi-remote dismantling;
(c) The reclassification of waste to a less hazardous category;
(d) Reduction of the volume of waste for disposal;
(e) The salvage of equipment, materials or premises, including clearance for unrestricted use;
(f) Reduction in the overall cost of decommissioning.

6.8. Before any decontamination technique is selected, an evaluation of its effectiveness and of the potential for reducing total exposure should be performed. Safety related systems and structures should be assessed for compatibility with decontamination solutions and processes that may be used during decontamination to ensure they will not be degraded and become ineffective. This evaluation should include:

(a) The probable radiation doses involved;
(b) The decontamination factor likely to be achieved;

(c) A cost–benefit analysis comparing the radiological benefits and waste management benefits of the decontamination effort with the expected costs;
(d) The probability that available techniques will achieve the target decontamination factor for the particular components of interest;
(e) The ability to demonstrate by measurement that the target decontamination factor has been achieved;
(f) An assessment of the potential impact on the workers and the environment;
(g) Assessments of the primary and secondary wastes arising from the decontamination, including their treatment volumes, nature and activity.

6.9. Consideration should be given to the compatibility of waste with existing systems for treatment, conditioning and disposal. In any case, before waste is generated, adequate arrangements for disposal or storage should be in place.

DISMANTLING

6.10. There are many options available for dismantling, and their selection depends on the types and characteristics (size, shape and accessibility) of the equipment and structures to be dismantled. Each dismantling task should be analysed to determine the most effective and safe method to perform it. Some considerations are as follows:

(a) The dismantling equipment to be used should be reliable and simple to operate, decontaminate and maintain.
(b) There should be effective methods available for controlling airborne radionuclides.
(c) The effects of each dismantling task on adjacent systems and structures and on other work in progress should be evaluated.
(d) There should be effective methods available for controlling hazardous materials other than radiological materials.
(e) The waste containers and the associated handling systems and routes for movement should be designated prior to the start of dismantling work.
(f) The operating organization's training requirements should be determined.
(g) The time necessary to perform the dismantling task should be evaluated.

6.11. Wherever possible, the material removed during the dismantling activities should be placed into a final disposal container. This prevents the double handling of waste, which can result in increased doses and the possible spread of contamination. However, this might not be possible if conditioning of the waste is necessary.

6.12. Special tools and devices may be needed during the dismantling activities. In such cases, these tools and devices, together with the techniques for their operation and maintenance, should be tested in simulated conditions before their use. Maintenance and periodic testing of these tools and devices should be included in the design and deployment strategy for them.

6.13. Computer based as well as physical mock-ups can be used to plan dismantling tasks, to evaluate options, to aid in the design of tooling and to train personnel.

DEMOLITION

6.14. In many cases, activities for decontamination and dismantling are aimed at making the demolition of the building structure a non-radiological activity. Where demolition of structures involves radioactively contaminated material, the safety considerations set out previously for decommissioning activities should be applied. Care should be exercised during demolition to ensure that contaminated material is segregated from non-contaminated material.

SURVEILLANCE AND MAINTENANCE

6.15. If activities for decontamination and dismantling are deferred in part or in whole for any reason, it is required "to ensure that there is clear and unequivocal allocation of responsibility for safety during the entire process of predisposal management of radioactive waste" (Ref. [2], para. 3.2). Safety should be ensured through a proper surveillance and maintenance programme. If a facility is entombed, a reduced surveillance and maintenance programme may still be necessary.

6.16. Before a facility is put into a surveillance and maintenance mode, the risk of potential incidents should be minimized; for example, bulk process radioactive materials and operational waste should be removed. Consideration should be given to removing, containing or immobilizing any remaining loose contamination where practicable.

6.17. The following activities should continue to be performed during this phase:

(a) Maintenance of appropriate systems for physical protection commensurate with the risk entailed;

(b) Monitoring, surveillance and inspection, commensurate with the level of hazard;
(c) Maintenance of essential equipment, such as equipment for ventilation, mechanical handling and monitoring;
(d) Maintenance of the facility and the barriers and/or containment structure;
(e) Maintenance of documentation about the surveillance and maintenance activities performed;
(f) Maintenance of a financial mechanism to guarantee that funds are available for decommissioning when necessary.

FINAL RADIOLOGICAL SURVEY

6.18. At the completion of decontamination and dismantling activities, a radiological survey of the facility shall be performed to demonstrate that the residual activity is acceptably low and within the criteria set by the national regulatory body and that the decommissioning objectives have been fulfilled (Ref. [2], para. 6.11). The design and implementation of the survey should be discussed with the regulatory body during the planning period for the survey. This survey may be carried out in phases, as decommissioning work is completed, to enable parts of the facility or site to be released from regulatory control.

6.19. The criteria established by the regulatory body should be in terms of measurable quantities that can readily be compared with field measurements. The radionuclides present will influence the methods adopted. Sampling for chemical contamination could be combined with the radiological survey.

6.20. The survey data should be documented in a final survey report and submitted to the regulatory body. The report should include:

(a) The criteria used;
(b) The methods and procedures used to test compliance with the criteria;
(c) The measurement data, including appropriate statistical analysis.

6.21. The results of the survey shall be included in the final decommissioning report (Ref. [2], para. 6.13). The final decommissioning report should be in a form that allows it to be accessible by the general public. An example of the contents of such a final radiological survey report for a nuclear fuel cycle facility is provided in the Annex.

7. MANAGEMENT DURING DECOMMISSIONING

STAFFING AND TRAINING

7.1. A team of decommissioning specialists and appropriate site personnel should be formed to manage the decommissioning project. Although new competences may be necessary for the decommissioning phase, the retention of key personnel who were familiar with the facility during its operational phase would be beneficial for the project.

7.2. The operating organization should have, or should have access to, adequate competent staff to cover the following areas:

(a) Radiation protection;
(b) Decontamination;
(c) Robotics and remote handling;
(d) Engineering support (physics, instrumentation and chemical, civil, electrical and mechanical engineering);
(e) Dismantling and demolition;
(f) Quality assurance and quality control;
(g) Criticality safety;
(h) Safety assessment and risk assessment;
(i) Waste management;
(j) Project management and financial and/or cost control;
(k) Physical protection;
(l) Public information.

7.3. In some cases, contractors or personnel from similar facilities may be used to carry out all or some aspects of the decommissioning. The operating organization should ensure that adequate control, supervision and training specific to the facility being decommissioned are provided.

7.4. Personnel should be made familiar with the facility, the safety requirements of the licence, including requirements for radiation protection, and all safety procedures. Specialized training may be needed for certain activities. Care should be taken to adopt sound working practices and to maintain good working conditions. For some activities the use of mock-ups and models during training can significantly improve efficiency and safety.

7.5. Basic requirements for a training programme and for refresher training in decommissioning activities should be described in the decommissioning plan.

ORGANIZATIONAL AND ADMINISTRATIVE CONTROL

7.6. The organizational structure to be used during decommissioning should be described in the decommissioning plan. There should be a clear delineation of authorities and responsibilities, together with the interfaces and communication routes that will be used. This is particularly important when contractors or outside organizations are used.

7.7. In order to control all decommissioning activities, the operating organization should implement an effective management control system. This should include control of preparatory decommissioning activities (such as the installation of new safety systems) and recognition of the risks associated with the changing conditions that arise during decommissioning.

7.8. The organizational structure should be such as to ensure that the unit with the function of reviewing quality assurance is independent of the unit directly responsible for accomplishing the decommissioning activities.

7.9. Administrative measures from the operational phase of the facility may be relevant to the decommissioning. These measures should be reviewed and modified to ensure that they are appropriate and, if necessary, additional administrative measures should be taken. The administrative control measures may be required to be endorsed by the regulatory body.

7.10. In the event that decommissioning is deferred, the knowledge of the facility's history accumulated by personnel associated with the facility prior to its final shutdown should be documented. This information should be made available to decommissioning workers for use during all phases including the planning, decontamination and dismantling phases.

STRUCTURES, SYSTEMS AND COMPONENTS IMPORTANT TO SAFETY

7.11. Equipment that is important for ensuring safety during decommissioning should be identified, installed or replaced if necessary, and maintained. Some of this equipment will be available from the operational period of the facility but it should be assessed both for suitability in the changing circumstances of decommissioning and also for the extension of the period of use. A management system should be established to ensure that all equipment necessary for safety is periodically monitored and maintained to detect and remedy any degradation of its safety function. Advantage should be taken of existing structures for shielding and containment where applicable.

7.12. Maintenance of the safety related equipment and structures should be carried out both during the decommissioning phases and also during any intervening period of surveillance and maintenance.

RADIATION PROTECTION

7.13. The decommissioning operating organization should establish an organization for radiation protection that should be able to function independently in matters affecting the health and radiation safety of the workers and the public. Appropriate procedures should be formulated and implemented, which may be the same as those already established during operation and maintenance of the facility. However, during decommissioning, additional emphasis should be placed on mitigating the following hazards:

(a) The closer proximity of radiation sources to operating personnel, and hence the greater potential for radiation exposure;
(b) The greater potential for the creation of airborne radionuclides, due to the need to breach the containment or barriers during dismantling;
(c) The introduction of new techniques necessitating specific controls and adequate training of personnel.

ON-SITE AND OFF-SITE RADIOLOGICAL MONITORING

7.14. The operating organization should ensure that on-site and off-site monitoring is conducted during decommissioning. Programmes for both on-site and off-site monitoring inherited from the operational period may necessitate modification appropriate to the conditions prevailing during decommissioning.

7.15. On-site monitoring should be conducted to provide information to identify radiological hazards and to assist in their reduction. It should be ensured that all potential work areas and discharge points are monitored. On-site monitoring should include not only personnel monitoring but also appropriate area monitoring.

7.16. Off-site discharges of radionuclides via air and liquid pathways should be controlled, monitored and recorded, as authorized by the regulatory body. Relevant recommendations are provided in Ref. [8]. The corresponding recommendations for non-radiological releases should also be met.

7.17. On-site and off-site monitoring and radiation and contamination surveys, as well as safety analyses and assessments, should be used to gauge the expected and actual degree of safety associated with decommissioning activities.

WASTE MANAGEMENT

7.18. Operating organizations should ensure that the waste management plan, which is part of the decommissioning plan, is implemented.

7.19. In managing the waste from decommissioning, several factors should be considered. These include:

(a) The origin, amount, category and nature of the waste that will be generated during decommissioning and the minimization of the waste (relatively large quantities of radioactive waste may be generated in a short time);
(b) The possibilities for removal of radioactive waste from regulatory control;
(c) The possibilities for the reuse and recycling of materials, equipment and premises;
(d) The generation of secondary waste and its minimization;
(e) The presence of non-radiological hazardous materials, such as asbestos;
(f) The availability of waste recycling or treatment plants, storage facilities and disposal sites;
(g) Any special requirements for the packaging and transport of radioactive waste;
(h) The traceability of the waste;
(i) The possibilities of inadvertent criticality;
(j) The potential impact of the waste on the workers, the public and the environment;
(k) The criteria for segregating materials;
(l) The methods proposed for treatment, conditioning, transport, storage and disposal of waste.

7.20. Waste generated during the decommissioning process should be segregated according to the strategy for waste management at the site. Such a segregation is essential to minimize the volumes of waste in higher categories and should enable the proper conditioning, disposal or reuse of the material.

7.21. A large part of the waste and other materials arising during the decommissioning process may be sufficiently low in activity concentration for regulatory control to be wholly or partly removed. Some waste may be suitable for disposal in normal landfill sites, while some materials such as steel and concrete may be suitable for recycling

or reuse outside the nuclear industry. The removal of regulatory controls should be accomplished in compliance with criteria established by the national regulatory body. Guidance on criteria for the removal of regulatory controls and on the management of the regulatory process for the removal of controls will be developed in other IAEA safety standards.

7.22. The waste management plan should be capable of coping with the additional waste from decommissioning activities and from secondary waste streams, including waste resulting from unplanned events or incidents during decontamination, dismantling and demolition. If existing waste processing systems cannot cope with the waste generated during decommissioning in the volumes proposed, the construction of new facilities should be considered. Consideration should also be given to minimizing cross-contamination and the generation of secondary waste. Requirements for the pre-disposal management of radioactive waste are established in a Safety Requirements publication [2].

7.23. Significant reductions in volumes of radioactive waste can be achieved by means of decontamination programmes, controlled dismantling techniques, contamination control, sorting of waste materials, effective processing and, in some cases, administrative controls. Reuse and recycling strategies have the potential for reducing the amounts of waste to be managed. Similarly, the release of material with low activity from regulatory control as ordinary waste or for reuse and recycling can also substantially reduce the amount of material that should be considered radioactive waste.

7.24. The radiation exposure to the workers and the public may vary according to the waste minimization strategy. An integrated approach should be used to balance waste minimization goals with the objective of keeping radiation exposures as low as reasonably achievable while taking into account increased handling risks and costs.

7.25. Transport of radioactive waste off-site should conform to national regulations. International requirements for the transport of radioactive material are provided in Ref. [10]. Precautions should be taken to prevent the external contamination of disposal containers that could leach contaminants during transport.

7.26. The management and staff involved in the decommissioning project should be made aware of and trained, if necessary, in the methods necessary to minimize the waste generated in the tasks assigned. Such methods include using tents for control of contamination, the containment of spills and the segregation of radioactively contaminated waste from waste that is not radioactively contaminated.

EMERGENCY PLANNING

7.27. A programme for emergency planning shall be established (Ref. [2], para. 3.14) and described in the decommissioning plan. This programme should be subject to approval by the regulatory body. Operating organizations should ensure that procedures to deal with unforeseen events are prepared and are put in place. Personnel should be trained in emergency procedures. Provision should be made for regular testing and updating of these procedures by conducting exercises periodically.

PHYSICAL PROTECTION AND SAFEGUARDS

7.28. Appropriate physical protection for the facility, commensurate with the associated hazards, should be maintained throughout decommissioning [11]. If the facility contains materials subject to safeguards, the operating organization should adhere to the relevant international agreements and should comply with IAEA safeguards principles [12, 13].

QUALITY ASSURANCE

7.29. An appropriate updated quality assurance programme shall be implemented by the operating organization (Ref. [2], para. 3.12). Activities for decontamination, dismantling and waste management should be performed by properly trained individuals and in accordance with approved working procedures. Working procedures should be prepared for each decommissioning activity. The need for the acquisition and retention of records and information relevant to the facility being decommissioned should be emphasized in the development of a quality assurance programme for decommissioning.

7.30. Records should be maintained of each task carried out in the decommissioning operation. Accurate and complete information concerning the locations, configurations, quantities and types of radionuclides remaining in the facility is essential and should be acquired and maintained. For final dismantling, these records should be used to demonstrate that all radioactive materials that were present at the beginning of decommissioning have been properly accounted for and that their ultimate destinations and uses have been identified and confirmed. This documentation should also account for materials, structures and land that have been removed from regulatory control.

8. COMPLETION OF DECOMMISSIONING

8.1. On completion of decommissioning, appropriate records should be retained as specified by the regulatory body. These records should be held and maintained for purposes such as confirmation of the completion of decommissioning in accordance with the approved plan. The confirmation of the completion of decommissioning should include information on the disposition of waste, materials and premises.

8.2. A final decommissioning report shall be prepared (Ref. [2], para. 6.13), on the basis of the records assembled, and should contain the following information:

(a) A description of the facility;
(b) The decommissioning objectives;
(c) The radiological and non-radiological criteria used as a basis for the release of the equipment, buildings or site from regulatory controls, or for any other control regime approved by the regulatory body;
(d) A description of the decommissioning activities;
(e) A description of any remaining buildings or equipment not decommissioned or partially decommissioned;
(f) The final radiological survey report;
(g) An inventory of radioactive materials, including amounts and types of waste generated during decommissioning and their locations for storage and/or disposal;
(h) An inventory of non-radioactive materials, including amounts and types of waste generated during decommissioning and their locations for storage and/or disposal;
(i) An inventory of materials, equipment and premises released from regulatory control;
(j) A list of structures, areas or equipment designated for restricted use or properly covered by deed restrictions;
(k) A comparison of actual volumes of waste generated during decommissioning activities with the amounts projected in the planning phase;
(l) A summary of any abnormal events and incidents that occurred during decommissioning;
(m) A discussion of the status of the removal of controls and any remaining restrictions on the site;
(n) A summary of occupational doses and public doses received during decommissioning;
(o) The lessons learned during the decommissioning process.

8.3. This report provides the confirmation of completion of decommissioning and should be reviewed and approved by the regulatory body. Any remaining restrictions on the site should be registered as required by national regulations.

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Annex

EXAMPLE OF THE CONTENTS OF THE FINAL RADIOLOGICAL SURVEY REPORT

FACILITY NAME

FACILITY DESCRIPTION

Type and location of facility
Site description
Ownership
Description of the facility
Hazards

BACKGROUND

Reason for decommissioning
Management approach

OPERATING HISTORY

Licensing and operations
Processes performed
Waste disposal practices

DECOMMISSIONING ACTIVITIES

Objectives
Results of previous surveys
Decontamination and dismantling procedures

ACTIVITIES FOR WASTE MANAGEMENT

Generated quantities of waste (volume, activity)

Treatment and conditioning
Disposal, including on-site and/or off-site shipment

FINAL SURVEY PROCEDURES

Sampling parameters
Background/baseline levels identified
Major contaminants identified
End point radiological criteria
Equipment and procedures selected
Instruments and equipment
Techniques for instrument use
Procedures followed

FINDINGS OF THE SURVEY

Summary of findings
Techniques for reducing/evaluating data
Statistical evaluation
Comparison with radiological criteria for the end point
Assessment of acceptability

SUMMARY

ATTACHMENTS

Detailed survey data with drawings

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