Australian Government
Australian Radiation Protection and Nuclear Safety Agency

arpansa

# REGULATORY GUIDE: Decommissioning of Controlled Facilities

**REGULATORY SERVICES**

**REG-LA-SUP-XXXX**

**DRAFT**

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# Contents

# 1. Introduction

## Background

1.1 Decommissioning refers to administrative and technical actions taken to allow removal of some or all of the regulatory controls from a facility (except for a radioactive waste disposal facility, which is, by definition, subject to closure and not decommissioning) [1]. 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 taken on the basis of planning and assessment to ensure safety during decommissioning operations.

1.2 Adequate planning and implementation of decommissioning are required to ensure the protection of the workers, the public and the environment.

1.3 The period for decommissioning activities may typically range from a few months to decades (for example, to allow for radioactive decay) and may include phased release of parts of a site or facility from regulatory control. Dismantling may occur immediately after shutdown or deferred until after a safe enclosure period. On completion of decommissioning and on reaching the desired end state the facility and site will be available for restricted or unrestricted use.

1.4 While much of the decommissioning activity takes place in the final phase in the lifecycle of the facility, planning for decommissioning nominally begins during facility design and continues through all phases of the facility lifecycle. Experience has shown the importance in considering decommissioning for new facilities at the design stage, developing an initial decommissioning plan, and periodically updating the initial decommissioning plan during and at the conclusion of the operational phase. The subsequent objective is to develop a final decommissioning plan prior to the start of decommissioning activities.

1.5 In particular, this guidance document is based on the safety requirements of the IAEA General Safety Requirements (Part 6): Decommissioning of Facilities [1] and is drawn mainly from the IAEA guidance, found in the supporting IAEA Draft Safety Guide: Decommissioning of Nuclear installations [2], on how to meet the requirements. This document is written in the context of the legislative and regulatory framework of the Commonwealth of Australia for the nuclear installations owned by Commonwealth entities, but can be applied generally in other jurisdictions.

1.6 Terms defined in the Australian Radiation Protection and Nuclear Safety Act 1998 (the Act) [3] and the Australian Radiation Protection and Nuclear Safety Regulations 1999 (the Regulations) [4] have the same meaning in this Regulatory Guide. All other terms in this Guide are intended to be consistent with the definitions in the IAEA Safety Glossary [5].

## Objective

1.7 The objective of this Regulatory Guide is to provide guidance to licence holder, technical support organisations, and other interested parties on planning, conducting and completing the decommissioning of nuclear installations. It aims to assist in ensuring that the decommissioning of these facilities is conducted in a safe and environmentally acceptable manner in accordance with good international practice. This document is also used for regulatory assessment of a licence application for decommissioning a controlled facility.

## Scope

1.8 This document provides guidance on planning for decommissioning, conducting decommissioning actions and terminating the authorisation of nuclear installations, such as research reactors, radioisotope production facilities, spent fuel management facilities and radioactive waste processing and storage facilities. It does not cover facilities using naturally occurring radioactive material (NORM) or medical, industrial, research and radioactive waste disposal facilities. The document provides recommendations to assist in fulfilling the basic safety requirements for decommissioning. It includes guidance on the relevant safety and regulatory aspects, application of the graded approach, selection of the appropriate decom-missioning strategy, key considerations in facilitating decommissioning during design, construction and operation, development and review of decommissioning plans, main aspects of radiation protection for decommissioning, safety assessment, funding, decommissioning management, transition from operation to decommissioning and termination of the authorisation.

1.9 This Regulatory Guide addresses related considerations and activities for the decommissioning of nuclear research reactors, radioisotope production facilities, spent fuel management facilities and radioactive waste processing and storage facilities from design until completion of decommissioning. On the basis of general considerations regarding safety, radiation protection, protection of human health and the environment and regulatory aspects, this document provides guidance on the selection of a decommissioning strategy, development of initial and final decommissioning plans and implementation of decommissioning management principles. Several key decommissioning tasks are also discussed.

1.10 This Regulatory Guide mainly addresses the radiological hazards resulting from the activities associated with the decommissioning of these nuclear installations and the management of waste and materials arising from the decommissioning operations, after a planned shutdown. Many of the considerations are also applicable to decommissioning after an abnormal event or an unanticipated shutdown that has resulted in serious damage or contamination. In these cases, this Regulatory Guide may be used as a basis for developing special decommissioning provisions.

1.11 In the event that part of a facility is being decommissioned, this Regulatory Guide only applies to the decommissioning activities. However, the potential safety implications with respect to the interaction between any decommissioning work and any continuing facility operations should be addressed on a case-by-case basis.

## Structure

1.12 The structure of this Regulatory Guide is arranged to accommodate both the features of decommissioning common to all facilities, as well as those which are special to the categories of nuclear installations: (i) nuclear research reactors and (ii) other nuclear installations such as radioisotope production facilities, spent fuel management facilities. Section 2 briefly addresses the issues related to protection of human health and environment including the application and consequences of a graded approach for the whole decommissioning process and radiation protection. Section 3 describes the responsibilities of the major parties associated with decommissioning. The factors influencing the selection of the decommissioning strategy are discussed in Section 4. The planning of decommissioning at the design, construction, operation, transition from operation to decommissioning and decommissioning phases of the facility lifecycle, are reviewed in Section 5. Sections 6 and 7 describe the funding and the management of decommissioning, respectively. Section 8 describes the conduct of decommissioning for the

categories of these nuclear installations. Section 9 discusses the completion of decommissioning including surveys to support the termination of decommissioning activities.

1.13 Appendix I discusses the process for selecting a decommissioning strategy for a nuclear installation. Appendix II provides a general content of a decommissioning plan. Appendix III provides information on the removal of regulatory control over materials, facilities and sites. Appendix IV provides an example of the contents of a final radiological survey report. Appendix V provides an example of the coverage of documents reporting the completion of decommissioning.

# 2. Protection of Human Health & the Environment

**Requirement 1: Optimisation of Radiation Protection and Safety in Decommissioning**

The licence holder must consider exposure during decommissioning as an authorised planned exposure and the relevant requirements of RPS F-1 and RPS C-1 must be applied accordingly during decommissioning.

2.1 The principles of radiation protection and safety for practices are provided in RPS F-1 Fundamentals for Protection against Ionising Radiation (2014) [6], which is based on the IAEA Safety Fundamentals [7]. The principles of justification of activities causing exposures to radiation, optimisation of exposures, limitation of exposures, and protection and safety being commensurate with the radiation risks, must be applied during decommissioning of controlled facilities. The activities associated with the decommissioning of a facility must be considered to be part of the original practice and the requirements of RPS C- 1 [8] must be enforced during all decommissioning activities.

2.2 During decommissioning, the workers, the public and the environment should be properly protected from radiological and non-radiological hazards. The licence holder must comply with the exposure limits for workers and the public in Part 5 of the Regulations [4] and the environmental discharge limits specified in the licence. A radiation protection program should ensure that radiation protection of workers and the public is optimised during decommissioning. Optimisation should be implemented, taking into account the specifics of the decommissioning project [1].

2.3 The licence holder should consider the radiation protection of both workers and the public, not only during the course of decommissioning but also when a site is to be released with restrictions on its future use [1].

2.4 Consideration should be given during decommissioning to protection against and mitigation of potential exposures from incidents or accidents[1]. The licence holder for a facility that is undergoing decommissioning must manage and control activities to mitigate impacts on the environment of the site and the surrounding area. These arrangements should be maintained during decommissioning and beyond if a facility is released with restrictions on its future use. The required end state conditions must be met before a site or a facility is released with no restrictions.

2.5 The licence holder should undertake a safety assessment to define protective measures using an optimisation approach for radiological protection with due regard for radiological safety. Such assessment should take into account all relevant hazards, and structures, systems and components (SSCs) (e.g. ventilation system, drainage) and their corresponding safety functions. It should be

[1] IAEA safety standards give guidance for each situation ([1] and [9])

noted that some of the SSCs will continue to be required during decommissioning and decommissioning can also give rise to the need for new safety functions and SSCs. These need to be considered to ensure overall safety during decommissioning.

2.6 The licence holder should foster and maintain a holistic approach to safety which addresses the technology, the individual or human, and the organisation, and the interactions between them, to both create and maintain safe operations and reduce the relative risk[2].

2.7 Appropriate training on health, safety and environmental matters should be provided to individuals engaged in decommissioning activities.

2.8 During decommissioning, radioactive and non-radioactive effluents may be discharged to the environment. These discharges must be controlled in compliance with licence conditions.

2.9 Radioactive waste management is further discussed in Sections 5 and 8. Radiological criteria for the removal of regulatory control from materials, facilities and sites is discussed in Section 9 and further guidance is provided in other IAEA Safety Standards [10-11].

2.10 The transport of radioactive material must satisfy the Code: Safe Transport of Radioactive Material Radiation Protection Series C-2 (2014) [12], which adopts the IAEA Transport Regulations [13].

## Graded approach to decommissioning safety

**Requirement 2: Graded Approach**

The licence holder must apply a graded approach to all aspects of decommissioning in determining the scope and level of detail for any particular facility consistent with the magnitude of the possible radiation risks arising from the decommissioning.

2.11 The range of decommissioning activities for controlled facilities is broad, and the scope, extent and level of detail of planning, safety assessment and demonstration, preparation, review and update of safety related documentation should be commensurate with the types and magnitude of hazards, and their potential consequences to workers, the public and the environment. Therefore, a graded approach should be applied to the planning, conduct and completion of decommissioning, and release of the site for unrestricted use or with restrictions on its future use [1]. The graded approach should be applied in a way that does not compromise safety and ensures compliance with all relevant safety requirements and criteria.

2.12 The application of the graded approach in the context of controlled facilities should take into account factors such as:

(a) size and type of the facility (including its complexity and consideration of historical burial of waste from past practices);

(b) physical state of the facility, specifically the integrity of the SSCs. In particular, the extent to which ageing or abandonment may have compromised building structures or SSCs, for example, due to a long period of poor maintenance;

(c) radiological (source term), biological and chemical inventories and hazards associated with the decommissioning of the facility;

[2] ARPANSA's Holistic Safety Guidelines provides further guidance

(d) lifecycle stage of the facility (design, construction, commissioning, operation, shutdown or decommissioning), such as the preparation of an initial decommissioning plan at a design stage or a preparation of a final decommissioning plan prior to planned shutdown;

(e) scope of the safety assessment (e.g. for a part of a facility, a single facility at a multi-facility site or an entire site);

(f) extent to which the proposed decommissioning operations could adversely affect ongoing operations with safety significance elsewhere at the facility or at nearby facilities;

(g) uncertainty of information (e.g. the quality and extent of the characterization of the facility) and the reliability and availability of relevant supporting information (e.g. drawings and records of modifications) to be used as input data for the safety assessment;

(h) complexity of the decommissioning tasks; and

(i) final end state of the decommissioning of the facility (e.g. unrestricted or restricted use).

## Assessment of Safety

**Requirement 3: Assessment of Safety**

The licence holder must assess the safety of all facilities for which decommissioning is planned and for all facilities undergoing decommissioning.

2.13 A safety assessment must be developed that demonstrates that the facility can be decommissioned without undue risk to the health and safety of people and the environment and to establish the necessary limits and conditions for maintaining safety during decommissioning. The safety assessment should establish the hazard category of the facility and be conducted to the depth and rigour that reflects the hazard categorisation using a graded approach. The more serious the potential risk the more onerous is the task of demonstrating that further protection is not needed.

2.14 The safety assessment should be developed and documented by the licence holder, approved by ARPANSA, and maintained current throughout the decommissioning program.

2.15 More detailed discussion of safety assessment is found in Section 7.

## Radiation Protection

2.16 A radiation protection plan should be included as part of the decommissioning plan and should be based on the national requirements for radiation protection set down in the Code: Radiation Protection in Planned Exposure Situations, Radiation Protection Series C-1 (2016) [8]. Regulatory expectations for the radiation protection plan are found in the Regulatory Guide [14].

2.17 During decommissioning activities, the principal focus of radiation protection is the protection of workers against normal and potential occupational radiation exposure. Consideration must be given to the protection of workers undertaking interventions in the event of an emergency. Radiation protection of workers and the members of the public exposed as a result of decommissioning activities must be optimised with due regard to relevant dose constraints.

### Environment Protection

2.18 The licence holder must consider environmental protection to enable efficient management of decommissioning and define the controls to ensure that any impact to the environment of the site and the surrounding area is mitigated to the extent practicable within acceptable levels. An assessment of the radiological impact on the environment should be developed concurrently with the decommissioning plan (see Section 5). Environmental protection should be maintained during the entire decommissioning process and beyond if a facility is released with restrictions on future use.

2.19 Environmental monitoring should be conducted throughout decommissioning. All potential radioactive releases should be prevented or controlled at source. Where releases are expected and authorised by ARPANSA the releases should be monitored through identified release points. Off-site monitoring may be conducted to demonstrate the adequacy of the control over releases of radioactive materials to the environment. The Regulatory Guide [14] should also be taken into account in developing the Environment Protection Plan.

## 3. Responsibilities associated with decommissioning

**Requirement 6: Responsibilities of the Licence Holder**

The licence holder must implement planning for decommissioning and must carry out the decommissioning actions in compliance with the ARPANS Act & Regulations and conditions of the decommissioning licence. The licence holder is responsible for all aspects of safety and protection of the environment during decommissioning.

3.1 When a facility is taken out of service the licence holder is responsible for the safety of the facility during decommissioning until surrender of the licence. The licence holder should demonstrate that decommissioning can be undertaken safely without undue risk to the health and safety of people and the environment. In developing and implementing the final decommissioning plan the licence holder should take into account international best practice for protecting people and the environment.

3.2 The licence holder is responsible for:

(a) selecting the decommissioning strategy as the basis for preparing and maintaining decommissioning plans (initial and final) throughout the life of the facility;

(b) preparing all decommissioning related documents, including the decommissioning plans, safety and environment assessments, and any other information required by ARPANSA;

(c) submitting them for regulatory review and for implementing the authorised final decommissioning plan; and

(d) estimating the cost of decommissioning actions and providing assurances and resources to cover the costs associated with safe decommissioning, including management of resulting radioactive wastes.

3.3 The licence holder must obtain approval from the CEO of ARPANSA prior to conducting decommissioning activities.

# 4. Management of Decommissioning

## Management System

**Requirement 7: Integrated Management System**

The licence holder must apply an integrated management system to all aspects of decommissioning.

4.1 An integrated system for the management and implementation of decommissioning must be established as part of the licence holder's organisation, with the prime responsibility for ensuring that decommissioning will be conducted safely. The reporting hierarchy and lines of responsibility and authority must be such that they do not create conflicts between organisations and activities that could compromise safety during decommissioning.

4.2 The integrated management system must provide a single framework for the arrangements and processes necessary to address all the goals of the licence holder. These goals include safety, health, environmental, security, quality and economic elements.

4.3 The management system should be appropriate to the size, complexity and impact of the project in accordance a graded approach (see Section 2), have a quality system, and be continually assessed and improved during decommissioning.

4.4 The licence holder should plan and apply the management system before the commencement of decommissioning and should extend it to all phases of decommissioning. A description or reference to an approved management system including a definition of its scope and extent should be included in the final decommissioning plan. The system should include processes for the maintenance and archiving of documents and records relating to decommissioning and the performance of all work activities and operations for decommissioning.

4.5 General guidance on integrated management systems can be found in IAEA Safety Standards Series publications [15]. Guidance on management systems, for more complex decommissioning projects is provided in IAEA Safety Standards Series publication GS-G-3.1 [16] and GS-G-3.5 [17].

## Safety management

4.6 Within the integrated management system, safety is the most important issue overriding all other demands [15]. Safety management refers to those aspects of the management system that are put in place to ensure that acceptable levels of safety are maintained during decommissioning.

### *Holistic Safety*

4.7 The management system is key to establishing a system for leadership and management for safety that will provide assurance that the operator has systems and procedures in place to identify, characterise and manage all safety issues including ranking the relative importance of risks so that available resources are deployed efficiently

The management system should foster and promote a culture of safety which takes into account human factors such as attitudes and behaviour as well as the general mindset by which all workers - including senior management - approach safety. These factors should interact with the

technological and organisational factors in a way that promotes holistic safety which is considered a best practice approach to safety management. A holistic approach to safety ensures the technology is safe to use; people perform tasks safely at work; and the organisation overall is managed safely. ARPANSA has developed Holistic Safety Guidelines on the implementation of holistic safety to which applicants should refer.

4.8 Safety management should include such organisational elements as:

(a) definition of the safety policy;

(b) identification of the main responsibilities, authorities and lines of reporting within the licence holder;

(c) arrangements for developing, regularly reviewing, updating and maintaining a current safety assessment demonstrating that the facility can be decommissioned safely and establishing operating limits and conditions for safety;

(d) arrangements for complying with, and amending, operating limits and conditions for safety;

(e) arrangements for gaining prior regulatory approval for changes having significant implications for safety;

(f) revision and updating the decommissioning plan as necessary;

(g) definition of the activities and competences necessary to ensure safety;

(h) arrangements to ensure that the activities of the licence holder are conducted safely;

(i) arrangements for approving safety related activities by the operating organisation's safety approval body and maintaining approvals current;

(j) establishing, implementing and maintaining a program of maintenance, periodic testing and inspection activities that enable safe decommissioning; and

(k) arrangements for maintaining a complete and current inventory of apparatus and radioactive materials controlled under the decommissioning licence.

4.9 The licence holder should take into account the Management System described in the Regulatory Guide [14].

# 5. Decommissioning Strategy

**Requirement 8: Selecting a Decommissioning Strategy**

The licence holder select a decommissioning strategy that will form the basis for planning for decommissioning.

5.1 The overall purpose of a decommissioning strategy is to serve as a basis for the decommissioning plan and in turn to achieve the end state of the decommissioning plan. The licence holder should develop a timely, cost effective strategy, that maintains high standards of protecting people and the environment should be developed [1] taking into account internationally accepted approach.

5.2 The decommissioning strategies should consider the three strategies defined by the IAEA namely: immediate dismantling, deferred dismantling and entombment 'no action' should not be regarded as an acceptable decommissioning strategy. For multi-facility site the licence holder should consider

interdependencies between the facilities both under operation and/or permanently shut-down for decommissioning.

5.3 The licence holder should justify the selection of a particular strategy and/or a combination of two strategies.

5.4 An evaluation of the various decommissioning strategies should be performed considering a wide range of factors for these nuclear installations. It should be ensured that the selected strategy meets all the applicable safety requirements. The selection of a preferred decommissioning strategy should be made by analysing factors such as [1]:

(a) compliance with the legal framework for decommissioning including adequacy and availability of financial resources, and radiological release criteria;

(b) proposed future use of the facility, site and the area adjacent to the site after decommissioning and the desired end state;

(c) characteristics of the facility, interdependences with other facilities or infrastructure located at the same site;

(d) physical status of the facility for the anticipated duration of deferred dismantling, including, if applicable, an assessment of the integrity of buildings, structures and systems;

(e) availability of expertise, technologies and infrastructure: experienced personnel and proven techniques, including decontamination, dismantling, and remote operating capabilities;

(f) environmental and socioeconomic impact, including public concerns about the proposed decommissioning activities;

(g) facility radiological condition: characterization of the facility, including the design and operational history, as well as the radioactive inventory after final shutdown;

(h) optimisation of radiological protection of workers, the public and the environment; and

(i) adequacy of arrangements for waste management including packaging, transportation, storage and disposal.

5.5 Appendix I provides a process that a licence holder could use and document in selecting a strategy for decommissioning a controlled facility. The selected strategy should be reviewed periodically in order to ensure that it remains appropriate in response to changing circumstances and influences.

# 6. Funding

**Requirement 9: Decommissioning Funding**

The licence holder must include responsibilities for funding in the decommissioning plan. Such provisions must include establishing a mechanism to provide and ensure adequate financial resources for safe and timely decommissioning

6.1 The licence holder must ensure that adequate financial provisions are available for decommissioning the facility in accordance with the regulatory framework. The cost of decommissioning should reflect all activities described in the decommissioning plan e.g. activities associated with planning for decommissioning, transition from operation to decommissioning,

conduct of decommissioning; and associated regulatory costs. The decommissioning costs should be based on an end state of unrestricted release of the site, unless ARPANSA has approved the restricted release option for the specific facility. Additional information on estimating decommissioning costs is provided in other IAEA publications.

Note: Regulation 41(e) requires the licence holder to show the capacity to comply with relevant regulatory requirements and conditions of the licence.

# 7. Decommissioning planning

**Requirement 10: Decommissioning Funding**

The licence holder must prepare a decommissioning plan and maintain it throughout the lifecycle of the facility to show that the decommissioning can be accomplished safely to meet the defined end state

7.1 Decommissioning should be facilitated by planning and preparatory work undertaken during the entire lifecycle of the facility [1] as shown in Figure 1 [2]. This work should be aimed at minimising the potential exposures of workers and the public, protection of the environment during decommissioning and reaching a desired end state to allow the release of the facility from regulatory control.

7.2 A decommissioning plan outlining the overall decommissioning strategy must be submitted to ARPANSA for approval.

7.3 For new facilities, an initial decommissioning plan should be submitted at the time of the licence application for construction. The plan should demonstrate: the feasibility of decommissioning the facility to achieve the desired end state; that the design of the facility appropriately considers and facilitates decommissioning; radiation protection to workers and the public; and minimises environmental impacts and waste generation, during decommissioning.

7.4 For existing facilities that do not have an approved initial decommissioning plan, a decommissioning plan should be prepared as soon as practicable and submitted for regulatory review (e.g. prior to final shutdown) in accordance with the licence conditions.

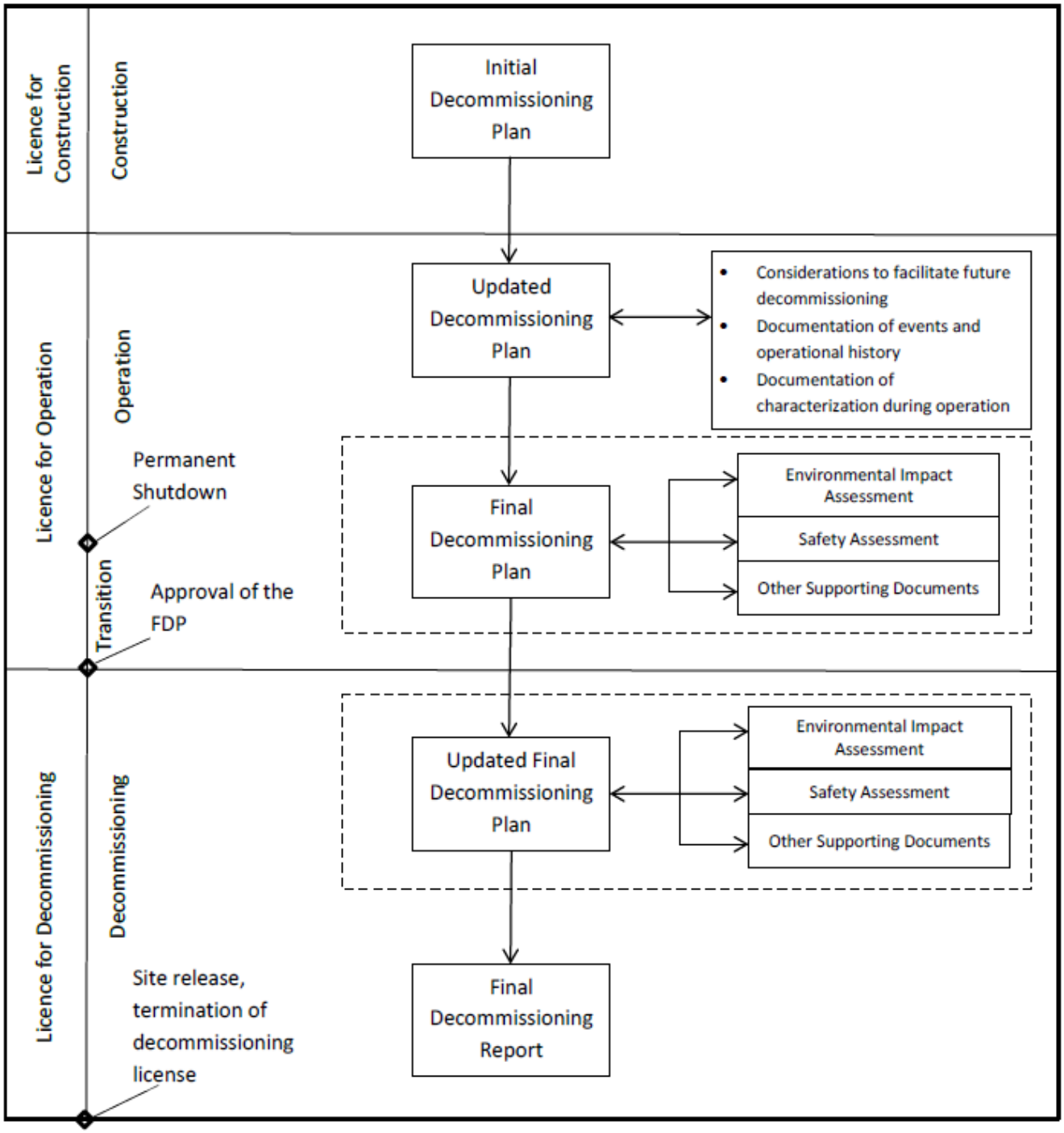
7.5 Nuclear installations that have been operating for many years might not have considered decommissioning at the design stage or during construction. This should be recognised in the planning for decommissioning for these facilities and preparations for decommissioning should start as early as practicable. Modifications to structures and systems should incorporate features that will facilitate decommissioning and enhance radiation protection to workers and the public and minimise environmental impacts and waste generation during decommissioning.

7.6 For multi-facility sites, the licence holder should have an overall strategy for decommissioning the site that takes into account the interdependencies of the individual facilities, the associated constraints and the individual facility decommissioning plans [1].

7.7 The licence holder must submit a safety assessment supporting the final decommissioning plan to ARPANSA. The extent of the safety assessment, its content and the degree of detail may vary depending on the complexity and hazard potential of the facility.

7.8 Historical records are essential to the planning of decommissioning. They should be kept throughout the lifecycle of the facility including siting, design, construction, and operation including modifications and shutdown.

**Figure 1: An example of decommissioning plan during the lifetime of the facility**



## Siting, design, construction and commissioning

### *Site baseline radioactivity*

7.9 The application for a licence to prepare site for a controlled facility should be accompanied by the results of a baseline radiological survey to establish the baseline levels of radiation and for use in assessing the future impact of the facility. The results should identify the key radionuclides and media (e.g. building material, soil and groundwater) to be measured that could be utilised for:

(a) evaluating the impact of the operation of the facility;

(b) determining the acceptability of decommissioning proposals (e.g. strategy and initial plan); and

(c) establishing and demonstrating compliance with an approved end state for the decommissioned facility.

### *Facilitating decommissioning*

7.10 During siting, design, construction and commissioning phases of a new facility, the licence holder should consider and implement features that facilitate decommissioning of the facility. Relevant features and aspects that should be considered include:

(a) minimising the number and size of contaminated areas, including compartmentalization of processes, to facilitate clean-up during decommissioning;

(b) facilitating access to process equipment, structures, systems and large components;

(c) equipment for facilitating dismantling, demolition, and disposal (such as appropriately rated cranes);

(d) using modular construction in order to facilitate the dismantling of structures, systems, and components not subject to ready decontamination (such as for easily separating mechanical and electrical components);

(e) providing for easy detachment, handling and remote removal of components that may become significantly activated;

(f) using layered or segmented concrete to ease demolition tasks and help separation of contaminated or activated material;

(g) providing for suitable access and egress routes for larger radioactive and contaminated items (this includes the location and size of access doors and/or oversize doors or hatches to remove components or install shielding), and adequate space around equipment for easy movement and working of personnel and/or tooling;

(h) minimising the use of underground pipework and of embedded pipes in the building structures;

(i) minimising the release of radionuclides during the decommissioning process and optimising radiation doses;

(j) using materials that facilitate decontamination, are resistant to activation, are resistant to degradation by chemicals and have sufficient wear resistance to minimise the spread of activated corrosion product;

(k) facilitating ease of decontamination of equipment and surfaces, including built-in decontamination mechanisms, such as protective coverings, bunds and liners in process cells and areas where liquids may be present;

(l) enabling remote decontamination, maintenance and monitoring where necessary;

(m) designing to avoid undesired accumulations of chemical or radioactive materials, and utilising processes that minimise and reduce the volumes of waste;

(n) enabling operational and temporarily stored wastes to be easily retrieved;

(o) providing adequate operational monitoring of vessels, the ground and water ways to detect leaks or releases early enough for effective mitigation; and

(p) minimising the use of hazardous substances that could result in mixed hazardous waste.

7.11 An application to ARPANSA for a licence to construct a controlled facility must be accompanied by a demonstration of the feasibility of safely decommissioning the proposed facility to achieve the desired end state.

### *Initial decommissioning plan*

7.12 The initial decommissioning plan must be consistent with the decommissioning strategy but will be limited in detail because the full information will not be available until facility operations cease.

7.13 The initial plan must be submitted to ARPANSA in support of an application for licence to commission and/or operate the facility. This plan should include discussion of:

(a) the selected decommissioning strategy, including the proposed end state of the decommissioned facility;

(b) the key decommissioning tasks and related basic safety issues;

(c) the radioactive waste management approach;

(d) measures taken during the design and construction stages to facilitate decommissioning;

(e) measures that will be taken to preserve skills and knowledge of the facility (i.e. knowledge management) and historical data and access to data;

(f) results of the radiological monitoring program of the site and surrounding area of the proposed facility, establishing the environmental baseline levels of radiation prior to facility's construction and before operation; and

(g) preliminary estimated cost of decommissioning the facility and the means of financing.

7.14 The existing facilities and equipment that could potentially be used during decommissioning should be identified early in the initial planning phase.

### *Update of initial decommissioning plan*

7.15 The licence holder should review the initial decommissioning plan and update it periodically during facility operations and as required by the Act, Regulations and licence conditions. The revisions should include consideration of:

(a) changes to the decommissioning strategy;

(b) changes in the proposed decommissioning end state for the site;

(c) changes in financial conditions or requirements;

(d) design or process modifications to the facility;

(e) operational and decommissioning experience feedback;

(f) availability of waste disposal capacity and acceptance criteria for waste disposal;

(g) new or revised safety requirements;

(h) new or revised regulatory requirements;

(i) technological developments in decommissioning techniques;

(j) plant life extension; and

(k) Incidents or accidents, changing the radiological inventory estimation.

7.16 Surveys of the facility should be conducted to determine inventories and locations of radioactive, fissile and other hazardous materials. The degree and extent of radioactive contamination that has occurred during operation should be clearly determined, characterised, classified, recorded and evaluated with regard to the decommissioning plan. An accurate characterisation of the facility is essential input for the safety assessment (including the criticality analysis, if needed) to be developed for the final decommissioning plan.

7.17 During each update of the initial decommissioning plan, the existing facilities and equipment identified for decommissioning should be reassessed as to their viability to support the proposed decommissioning activities and the proposed end states.

### *Records*

7.18 Records pertinent to initial decommissioning plan, updating the decommissioning plan and preparation for the final decommissioning plan should be used for effective and efficient decommissioning of the facility.

(a) Appropriate records and documentation related to operating history of the facility include:

i. design specifications and information from the siting, construction and commissioning, including as-built drawings, models, videos, photographs, piping diagrams, cable penetrations, material specifications, and other details helpful for decommissioning purposes;

ii. details of the weight, size, composition and location of equipment (including experimental devices, piping, penetrations, reinforcement bars) and impurities in their construction materials;

iii. fuel failures and fuel accounting;

iv. incidents leading to spillage or inadvertent release of radioactive material, including the recording of actions, corrective measures and close out;

v. radiation and contamination survey data, particularly for plant areas that are rarely accessed or especially difficult to access;

vi. releases of radioactivity that could potentially affect surface and ground water, and soil and sediment;

vii. radioactive source terms; and

viii. radioactive wastes and their location, quantity, form and activity.

(b) Records of modifications and changes to the design of the plant, and maintenance experience including:

i. updated 'as built' drawings, videos and photographs, including details of the materials used;

ii. evaluation and records of modifications and changes with respect to their future implication to decommissioning;

iii. special repair or maintenance activities and techniques (e.g. effective temporary shielding arrangements or techniques for the removal of large components);

iv. details of the design, material composition, and the history and location for all temporary experiments and devices; and

v. changes in operational feed and processes.

(c) Results of on-site and off-site radiological and environmental monitoring of soil and sediment, and ground and surface water;

(d) Records of on-site disposal of operational waste; and

(e) Event management, including the recording of actions, corrective measures and close-out information.

### *Unanticipated final shutdown*

7.19 If the final shutdown of a facility is unanticipated (e.g due to operational or financial viability, or an accident) the facility should be brought to a safe configuration by the licence holder. The decommissioning strategy and initial decommissioning plan must be reviewed in light of the causes of the unanticipated final shutdown and the consequences of and effects on the condition of the facility. Any remedial actions required as a result of the unanticipated final shutdown should be done under the operating licence. However, the funding allocated to decommissioning the facility must be reviewed and its adequacy made certain.

### *Transition from operation to decommissioning*

7.20 The transition from operation to decommissioning of a facility generally starts after the final shutdown (or cessation of operation) and may already cover parts of the preparatory activities for decommissioning. The end of the transition period is defined by regulatory approval of the final decommissioning plan and the issue of a licence to decommission the facility.

7.21 Some activities to facilitate decommissioning may be carried out under the operating licence after final shutdown of the facility. The licence holder must obtain prior approval from ARPANSA for these activities. Such activities could include:

(a) removal of spent fuel, operational wastes and residual fluids;

(b) facility modification and preservation of systems to facilitate decommissioning;

(c) decontamination of structures and system; and

(d) characterisation of the site and facility.

### *Final decommissioning plan*

**Requirement 11: Final Decommissioning Funding**

The licence holder must prepare and submit a final decommissioning plan to ARPANSA for approval prior to conducting decommissioning actions

7.22 Before the final shutdown of a facility, the licence holder should confirm the decommissioning strategy and initiate studies to accomplish that strategy in support of developing the final decommissioning plan. These studies should identify the existing systems, equipment and infrastructure (e.g. cranes, space conditioning and waste management systems) that will need to be maintained and used during decommissioning and also identify any new systems that will need to be installed prior to decommissioning.

7.23 The final decommissioning plan should address the elements presented in Appendix II.

7.24 The final decommissioning plan should present information describing the proposed decommissioning tasks including decontamination, dismantling, clean up and demolition of structures, systems and components; and remediation of surface and ground water, soil and sediment.

### *Records and reports of decommissioning*

7.25 Provisions should be made in the final decommissioning plan for maintaining records of each task carried out in the decommissioning process. Accurate and complete information concerning the locations, configurations, form, quantities and types of radionuclides remaining in the facility is essential and should be acquired and maintained. These records could be used to demonstrate that on completion of decommissioning all radioactive materials that were present at the beginning have been properly accounted for with their ultimate destinations and uses identified and confirmed. This documentation should also account for materials, structures and land that have been removed from regulatory control.

### *Phased approach to decommissioning*

7.26 For a larger decommissioning project, a phased approach is generally implemented to reach the objectives of the final decommissioning plan. The final decommissioning plan and the related phased approach should be supported by an overarching safety assessment report.

7.27 As an example, decommissioning based on immediate dismantling strategy could consist of the following phases:

Phase 1: Removal of radioactive waste and dangerous substances used and produced during the operating life of the facility (when this has not been done during the transition phase between operation and decommissioning

Phase 2: Preliminary operations to prepare the dismantling work (e.g. new working areas, supporting facilities, interim storage of wastes, etc.)

Phase 3: Dismantling operations in order to reduce the source term of the facility

Phase 4: Final clean-up activities (of buildings, etc.)

7.28 The phases could occur in parallel according the final decommissioning plan with each phase subdivided into discrete work packages or projects. The success of implementation of a phased approach is linked to the definition of clear objectives for each specific phase and the work packages making up the phase. The final decommissioning plan should define the starting and ending points of each phase and contained work packages that render the facility in an acceptable stable and safe state and have to be verifiable.

### *Schedule and sequence of decommissioning tasks*

7.29 The final decommissioning plan should provide a schedule for decommissioning phases, including the work packages within the phases and the time period required for completing the entire decommissioning. In developing the decommissioning schedule, the following matters should be considered:

(a) The timing of the start of decommissioning and the sequence in which decommissioning is carried out to optimise the dose received by occupational personnel. This should include the consideration of decommissioning the facility as soon as practicable following final shutdown so that the experience of staff with a working knowledge of the facility may be available to facilitate decommissioning and decommissioning is not unduly delayed (perhaps for economic reasons) in a way that compromises safety.

(b) Ensuring that decommissioning activities that generate radioactive waste are not started until waste disposal or storage facilities are available.

(c) In the case of a nuclear reactor, the early removal of major radioactive sources such as nuclear fuel, heat transport and other process fluids and contaminated materials. If the activity of a component is due mainly to relatively long-lived radionuclides, such as 137Cs, then decontamination or removal of the component early in the sequence might reduce occupational, public and environmental exposures. On the other hand, if high activity comes from short-lived radionuclides, then delayed removal for few years could be considered.

(d) Milestones and hold points such as:

i. removal of contaminated coolants and other readily removable contaminated and activated materials, including any stored radioactive waste;

ii. when systems containing radioactive material are in a stable condition and sealed;

iii. removal from service of ancillary non-essential systems; and

iv. regulatory inspection hold points required by ARPANSA (e.g. on completion of decommissioning phases or work packages).

### *Safety Assessment*

7.30 The final decommissioning plan must be supported by a safety assessment addressing the planned decommissioning activities and potential abnormal events and accidents that could occur during decommissioning. It should consider occupational, public and environmental exposures.

7.31 The safety assessment must employ a systematic methodology to demonstrate compliance with safety requirements and criteria for decommissioning, including for the release of materials,

buildings and sites from regulatory control. In addition, the safety assessment should be used to help ensure that interested parties are confident of the safety of decommissioning [18].

### *Overarching safety assessment report and detailed safety assessments*

7.32 An overarching safety assessment report should address the main safety issues and objectives of the final decommissioning plan and its phases. Based on the outcomes from the overarching safety assessment report, the licence holder should develop detailed safety assessments for each phase to demonstrate safety of activities foreseen in a given phase.

7.33 In addition, a given phase can be subdivided into discrete work packages or projects for which specific safety assessments can be performed. Detailed safety assessments for the first phases should be performed during the transition period while detailed safety assessment for the others phases may be performed later but prior to the beginning of such phases.

### *Safety assessment framework*

7.34 In all phases of decommissioning the workers, the public and the environment must be protected from hazards resulting from the decommissioning activities for both normal and abnormal situations. Safety assessments contain an analysis of radiological hazards associated with decommissioning activities and demonstrate compliance with the regulatory requirements and criteria. Non-radiological hazards should be evaluated when radiological safety is impacted.

7.35 The depth and rigour of the safety assessments should be commensurate with the complexity and potential hazard of the facility and its decommissioning and in case of deferred dismantling should take into account the safety of the facility during the period leading up to final dismantling.

7.36 Analyses of accident scenarios should be performed and protective measures should be proposed for preventing accidents or minimising the likelihood of their occurrence and for mitigating their potential consequences. Protective measures are either engineered or administrative controls that provide the necessary radiological protection. The protective measures may require changes to the existing safety systems that were used during operation of the facility. The acceptability of such changes should be clearly justified in the safety assessment.

7.37 The aim of the safety assessment is to determine the necessary safety functions during decommissioning and the related structures, systems and components (SSCs) important to safety in accordance with a graded approach. SSCs important to safety provide the means for preventing the occurrence of postulated initiating events that could lead to incidents or accidents, the control and limitation of accident scenarios, and mitigation of the potential consequences of accidents. 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 and engineering assessment.

7.38 Postulated initiating events that could lead to elevated radiation levels or release of radioactive material and associated hazardous substances should be identified. The resulting set of identified postulated initiating events should be confirmed to be comprehensive and defined in such a way that the events cover credible failures of the SSCs of the facility, and human errors that could occur during decommissioning activities. The set of postulated initiating events should consider both internal and external events.

7.39 Human factors are an important aspect of the safety of controlled facilities as the state of the facility changes frequently with decommissioning activities. A systematic safety approach should be implemented in order to minimise human errors (built in controls and procedural and equipment protective measures to workers to avoid the risk of contamination). The safety assessment should consider the human errors according to the complexity and hazard potential of the facilities concerned (e.g. large numbers of equipment, tanks, pipes and valves with unexpected remaining radioactive materials and contaminated liquid).

7.40 The likelihood of bounding external events should be assessed taking into account the decommissioning strategy and the site characteristics (e.g. seismic risks, flooding, extreme temperatures, influence from or dependence on any neighbouring facilities) and the likelihood of potential initiating events for incident/accident scenarios (e.g. human error, fire, flood, dropped loads, building/structure collapse/failure, and chemicals).

7.41 Dismantling may involve the deliberate destruction and removal of engineered SSCs that had fulfilled specified safety functions during operation of the facility (e.g. containment, shielding, ventilation, and cooling). If these safety functions are still required during decommissioning the associated SSCs should be maintained in an appropriate state. If this is not practicable these functions should be provided by suitable alternative means or SSCs (e.g. tents, temporary facilities, fire systems, electrical systems, and administrative procedures) for as long as the function is required on the basis of the safety assessment. The appropriateness of alternative means of fulfilling such functions should be demonstrated to the extent practicable. Procedures for changing safety functions during decommissioning should be justified and demonstrated in advance of their implementation.

7.42 Implementation of the safety assessment results should lead to defining operational limits and conditions (OLCs). OLCs are the set of rules that establish parameter limits, functional capability and performance levels required of equipment and personnel for safe decommissioning of the facility. The OLCs could include the required intervals for periodic testing and inspection of SSCs important to safety.

### *Consideration of radiological and non-radiological hazards in the safety assessment*

7.43 The licence holder should consider the following when assessing the radiological and non-radiological hazards during decommissioning of a controlled facility:

(a) presence and nature of all types of contamination;

(b) hazards associated with the possible in-growth of radionuclides (such as americium);

(c) potential for criticality hazards associated with the possible accumulation of fissile material during operation or during decommissioning activities;

(d) complexity of strategies for waste management due to the diversity of waste streams;

(e) for multi-facility sites, hazards associated with facilities that are not decommissioned;

(f) inaccessible areas and buried pipes;

(g) separation and concentration of material stored in tanks;

(h) hazardous chemicals located in SSCs, in the building, soil and sediment and surface and groundwater;

(i) changes in chemical and physical forms; and

(j) non-radiological hazards, such as fire or explosion, associated with both the operations and decommissioning activities.

### *Protection against radiological hazards*

7.44 After the cessation of operation, preparation for decommissioning often involves the removal of residual radioactive material and 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.

7.45 In the planning stage for decommissioning the degree and extent of contamination in a nuclear installation should be clearly determined, characterised, evaluated and classified. Surveys should be conducted to determine the inventories and locations of radioactive and other hazardous materials. An accurate characterisation of the facility will provide the input for the safety assessment.

7.46 Radiation exposures that could occur during decommissioning must be considered in the safety assessment. This should include external exposure from direct radiation and other radiation sources, potential criticality, internal exposure due to inhalation, ingestion or cuts and abrasions, and loss of containment leading to the uncontrolled release of radionuclides.

### *Shielding*

7.47 Protection against external exposure should be achieved by means of engineered provisions, such as adequate shielding and the use of remote handling equipment, and procedural and work controls. Radiation levels must be monitored to ensure that radiation exposures are within acceptable levels and so that any abnormal conditions would be detected and workers may be evacuated. Areas of potential exposure including 'hot-spots' for workers should be appropriately identified and marked.

### *Confinement*

7.48 During decommissioning the control of contamination is provided by confinement and leak detection. Confinement is achieved by means of physical barriers (e.g. static containment) and/or dynamic containment (e.g. by ventilation).

7.49 When dismantling process equipment, respiratory protective equipment of workers may be prescribed. In this case, respiratory protective equipment becomes the barrier which protects the operator from contamination. This equipment must be managed to ensure its functionality and compliance to regulatory requirements.

### *Criticality safety*

7.50 A balance between the assumptions undertaken to perform the criticality safety assessment for decontamination activities and the flexibility in the choice of decontamination techniques and procedures should be reached. Decontamination of equipment (such as highly contaminated glove boxes lines) could lead to the accumulation of fissile material during decommissioning or to the introduction of additional moderators.

7.51 A criticality safety assessment to ensure safety during waste treatment, conditioning and storage of waste packages and liquids should be performed.

### *Radioactive decay heat and radiolysis*

7.52 Heat generation should be taken into account during decommissioning due to the presence of high activity material (solid or liquid) in the facility.

7.53 During decommissioning of radioisotope production, spent fuel management facilities and waste storage facilities, special attention should be given to the difficulty in opening, characterisation, retrieval, and clean-up of storage tanks for highly radioactive liquid waste. Retrieval of the highly contaminated sludge with unknown or unexpected chemical and physical form should also be assessed as should the condition of solid wastes e.g. irradiated fuel, stored for long periods.

### *Consideration of non-radiological hazards in the safety assessment*

7.54 The safety assessment may identify a number of potentially significant non-radiological hazards, which may have radiological consequences during the decommissioning of the facility. These may include the lifting and handling of heavy loads; potential for drop of loads; the use of hazardous materials during the activities for decontamination and dismantling; adequacy of fire protection, especially during dismantlement; and structural integrity of buildings.

7.55 Design considerations should be made for fire safety on the basis of a fire safety analysis. Special attention should be given to the use of thermal cutting techniques (e.g. plasma cutting) and non-thermal cutting techniques (e.g. using grinder and saw) and the associated risk of fire during dismantling especially when mobile confinement tents and personal protective equipment are used.

7.56 Chemical, toxic, flammable or explosive substances can affect safety during decommissioning. To prevent this from occurring the following matters need to be considered during decommissioning:

(a) requirements and guidance contained in international and national standards and guidance on chemical safety;

(b) chemical compatibility of materials that are likely to come into contact;

(c) safe storage of hazardous materials for decontamination activities;

(d) detection and alarm capability for chemical or toxic releases;

(e) minimization of inventories; and

(f) personal protective equipment to protect against exposures to chemical compounds or toxic materials.

7.57 Although the method for dealing with most of the non-radiological hazards should be managed according to regulations, a strong holistic approach to safety will help to ensure that such hazards are identified and adequately controlled.

### *Radiation protection resulting from safety assessment*

7.58 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 possible deterioration of SSCs. In addition, considerations should be given to

the materials of physical barriers and process equipment for which mechanical properties may have changed during operation due to factors such as fatigue (e.g. from cyclic mechanical or thermal loadings), stress corrosion, erosion, chemical corrosion or the induction of changes by irradiation. Decontamination activities implemented during decommissioning should consider the risk coming from the aging of physical barriers and process equipment.

7.59 If suitable alternative means (e.g. mobile tents and administrative procedures) are necessary when dismantling process equipment and physical barriers, the nature and number of the alternative means and their performance should be commensurate with the degree of the potential contamination hazards. Special attention should be paid to the potential dispersion of residual alpha emitters. In many situations mobile tents may become the first confinement barrier during decommissioning. The design of this first confinement barrier should be described in the safety assessment and justified (e.g. static confinement, ventilation, filtration systems, fire and mechanical resistance). The associated SSCs should be defined within the safety assessment and taken into account in the OLCs.

### *Conducting Decommissioning Actions*

7.60 This phase is the implementation and execution of the final decommissioning plan. Activities associated with decommissioning are described in Section 8 which discusses surveillance and maintenance, selection of decommissioning techniques, decontamination, dismantling, demolition, soil and sediment and surface and groundwater remediation, waste and material management during decommissioning, and surveys and inspections.

### *Update decommissioning-related documentation*

7.61 The final decommissioning plan, safety assessment and environmental impact assessment should be treated as living documents consistent with regulatory requirements. They should be modified throughout the course of facility decommissioning to reflect the current decommissioning strategy, facility status, and anticipated activities and work packages.

7.62 As decommissioning is undertaken there may be modifications to decommissioning activities resulting from the collection of new data, unexpected events, feedback of experience and other factors. To reflect this the final decommissioning plan and the related supporting documentation may subsequently need some revisions, amendments or further refinements during implementation as the decommissioning activities progress. These changes may have significant implications for safety and if so require prior approval by ARPANSA under Regulation 51 [4].

7.63 Such a situation may be expected when the phased approach is applied and there are significant periods of time between the decommissioning phases (e.g. deferred dismantling with a long safe enclosure period). Full details should be provided in the plan and associated documentation for the next phase of decommissioning with subsequent phases addressed in less detail. However, the licence holder is expected to provide full details for each phase before it starts.

7.64 Experience gained during a decommissioning phase could give rise to new data, information or ways of undertaking decommissioning tasks and require the modification to planning for subsequent phases. In such cases, subsequent sections of the decommissioning plan and associated documentation should also be reviewed and updated. The experience from previous decommissioning phases should be appropriately taken into account.

### *Update of final decommissioning plan*

7.65 In the case of complex decommissioning projects such as the decommissioning of nuclear research reactor it is possible that site conditions or circumstances may arise which the final decommissioning plan did not contemplate. To address this situation the final decommissioning plan should include an approved change control process. This should define categories of changes to the final decommissioning plan and associated documentation which have significant implications for safety and need prior approval under Regulation 51 and which allows minor changes with no such implications to be made directly by the licence holder under Regulation 52 [4]. Typically, prior approval would be required for any changes to the final decommissioning plan that would potentially result in a greater radiological hazard during or following decommissioning than was previously approved. Minor modifications to the final decommissioning plan to reflect current project or licence holder status could be implemented on a periodic basis.

### *Update of safety assessment*

7.66 The licence holder should review or prepare further safety assessments whenever the final decommissioning plan is revised or additional specific decommissioning work planning documents have been prepared to ensure the conclusions are still valid.

### *Update of environmental impact assessment*

7.67 The effects of modification of any decommissioning tasks or techniques on the environmental impact assessment should be considered. The environmental impact assessment should be updated when a previously unconsidered potential environmental impact is identified. The environmental impact statement should take into account requirements of applicable legislation.

### *Update of site and facility characterisation*

7.68 Information related to site and facility characterisation should be collected over the lifecycle of the facility and details of such information should be addressed in the final decommissioning plan.

7.69 A characterisation report should be prepared which documents the information and data obtained during the characterisation process. The characterisation report should be summarised or referenced in the decommissioning plan. It should be reviewed and approved by ARPANSA and available for audit or inspection.

## 8. Conducting decommissioning

**Requirement 12: Conduct of Decommissioning**

The licence holder must implement the final decommissioning plan including management of radioactive waste.

8.1 Conducting decommissioning actions is the implementation of the decommissioning strategy, activities and tasks described in the decommissioning plan. The conduct of decommissioning includes preparatory work related to decommissioning as well as specific decommissioning tasks.

### *Preparation for decommissioning*

8.2 The licence holder must maintain the facility in a safe status during the post operational phase. Depending on circumstances some of the aspects described in this section may be conducted during transition from operation to decommissioning.

### *Removal of residual process material*

8.3 Significant amounts of residual process material may be present in both planned and unplanned locations at the time of final shutdown. This material may consist of new and spent fuel, experimental and irradiation rigs and targets, and operational waste, as well as residual fluids. The removal of this material can be considered as part of the transition from operation to decommissioning or part of decommissioning.

8.4 The handling, storage and disposal of spent nuclear fuel and control absorbers should be addressed, including consideration of criticality of fuel in storage, shipment and disposal. Where relevant, the products of conditioning and preparation of fuel should be taken into account and, if the fuel is to be shipped, the availability of suitable ships and approved transport packages should be addressed. Management of spent fuel is more completely described in relevant IAEA safety guides.

8.5 The hazard associated with the radioactive inventory in irradiation rigs and experimental equipment requires particular consideration due to their portable nature. Measures should be in place to prevent them being improperly removed. Consideration should be given to their removal and disposal at an early phase in the decommissioning process when rig handling equipment and expertise may be in their most efficient state. Records should be maintained of rigs that have been removed and where they are located.

8.6 Timely removal of the residual process materials reduces the requirements for monitoring and surveillance. Other activities associated with decommissioning such as characterisation may be conducted concurrently with the removal of residual fluids but potential interactions should be identified and assessed.

8.7 Residual material and operational radioactive waste should be removed from the facility prior to shutdown, as the safety implications for some of the decommissioning tasks will be less onerous and the SSCs will be characterised accordingly. If operational wastes or residual fluids remain, the safety assessment for the decommissioning tasks may be more complex and may make the decommissioning activities less efficient and increase doses to the operators.

8.8 Even when the bulk of the residual process material has been removed a significant amount of radioactive contamination may remain in the process systems. Preliminary clean-up or decontamination of process equipment may be performed during transition,

8.9 Consideration should be given to physical protection measures. For example, when it is not possible to remove the spent fuel and some operational wastes from the facility, an option could be to move it to a designated storage area within the facility and downgrade the physical protection measures in other areas of the facility.

### *System decontamination*

8.10 From a radiological point of view, it may be appropriate to carry out full circuit decontamination of piping systems before preparing the final decommissioning plan or conducting decommissioning. This could have the benefit of reducing the workforce doses and might also provide for a wider range of techniques for dismantling and related waste management routes e.g. the compliance with transport requirements for large components and allowing external treatment.

### *Historical site assessment and operational history*

8.11 Baseline monitoring should be performed for all new sites/facilities as well as for new facilities on existing sites or for reuse of an existing site. The availability of base line survey information is essential for site/facility characterisation but may not exist. In such cases a baseline measurement should be performed as soon as it is recognised that such measurements are missing.

8.12 A historical site assessment should be performed and information surveys should be undertaken during the lifecycle of the facility and during transition from operation to decommissioning. Information surveys should cover the following:

(a) personnel interviews (with current and previously employed personnel);

(b) operational information including waste management;

(c) facility safety reports;

(d) facility modification reports;

(e) event reports; and

(f) baseline and earlier environmental and facility surveillance reports.

8.13 The results of the historical site assessment should be then used as basis for conducting the radiological characterisation.

### *Radiological characterisation*

8.14 Radiological characterisation establishes the inventory of radionuclides in materials that will require storage or disposal as radioactive waste or release from regulatory control and provides information needed to plan decommissioning activities, including:

(a) the scheduling and workforce requirements particularly with respect to exposure in the most radioactive areas;

(b) the need for protective equipment, shielding and remote operations;

(c) decontamination of SSCs;

(d) dismantling and removal of components and equipment;

(e) demolition of structures; and

(f) management of decommissioning waste.

8.15 The characterisation should include quantitative estimates and records of the type, amount, chemical and physical form, and location of important radionuclides, contaminated materials and other toxic and hazardous materials (such as beryllium, asbestos, inflammable and explosive materials) within the facility at the commencement of decommissioning. The information should be

recorded and maintained throughout the various phases of the decommissioning process and after decommissioning as historical records.

8.16 The quantitative estimates for radionuclides, contamination, toxic and hazardous materials should be of reasonable accuracy. Where these cannot be obtained directly, reasonably accurate estimates are required. Calculated estimates of radionuclide inventory should be verified, wherever practicable by means of direct measurement. In the case of nuclear reactors, various computer codes are available for calculating the induced activity in a reactor and its immediate surroundings to estimate the radioactive inventory.

8.17 Comprehensive characterisation of the radiological inventory comprises the following steps:

(a) review of historical information;

(b) implementation of calculation methods;

(c) preparation of the sampling and analysis plan based on an appropriate statistical approach;

(d) performance of in-situ measurements, sampling and analysis;

(e) review and evaluation of the data obtained; and

(f) comparison of calculated results and measured data.

8.18 In the case of research reactors, the radiological characterisation must include:

(a) residual radioactivity in the reactor systems, experiments facilities, irradiation rigs, control absorber, and undrained pockets in process circuits;

(b) radioactivity induced by neutron activation, such as $^{94}$Nb, $^{60}$Co and $^{55}$Fe, in a reactor's internal core structure, experiments facilities, irradiation rigs, and equipment inside the main biological shield of radioactive elements;

(c) radioactive substances deposited as contamination on the internal and external surfaces of various systems, including contamination from fuel, experiments facilities, irradiation rigs, and control absorbers;

(d) daughter radionuclides that become significant after periods of decay should be considered;

(e) residues of nuclear fuel, control absorbers, heat transport fluids and process fluids; and

(f) consideration of radioactive materials that are absorbed by or adhering to facility systems.

8.19 A fully detailed and accurate characterisation might not be possible at the beginning of decommissioning and this should be continually developed and improved as decommissioning progresses. However, detailed and accurate characterisation relevant to a particular decommissioning task must be available to allow final planning of the task before the task is undertaken.

8.20 Before and during decommissioning, an adequate number of characterisation surveys should be conducted to determine the radionuclides, maximum and average dose rates, and contamination and activation levels throughout the facility and in the soil, sediments and ground and surface water. Contamination and activation levels should be determined for the inner and outer surfaces of equipment and in soil and sediments.

8.21 Special surveys may be required to determine the penetration depth in concrete structures, soil and sediments and extent of contamination which is needed for the selection of appropriate

decommissioning techniques and methods. For completeness, contamination in shielded or self-shielded components such as inside pipes and equipment and in buildings as a function of depth should be determined.

8.22 Results of such characterisations 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. However, such surveys may need to be updated to account for radiological decay and the in-growth of daughter products.

8.23 Radiological characterisation data should include zone description (e.g. facility, environment ground and surface water, soil, and sediments), contamination and dose rate levels, chemical and physical forms of materials. Characterisation surveys should also identify adjacent uncontaminated zones. During decommissioning activities special attention should be given to prevent cross contamination of such zones. Radiological characterisation of the facility should describe contamination and activation levels.

8.24 The radioactive waste inventory including waste that has both radionuclides and hazardous constituents should be also performed by type, waste description, processing status, location and radiological and hazardous materials conditions.

8.25 The following are special cases where care should be taken during characterisation:

(a) fissile material inventories where criticality events may occur since uncertainty about the amounts or presence of fissile material could have severe consequences if assessments for criticality are incomplete or wrong;

(b) with liquid or gaseous effluents or ponds which were utilized for storage or evaporation;

(c) where unplanned cessation of operation occurred;

(d) where failures of spent fuel elements occurred;

(e) where waste was buried;

(f) where previous decontamination/remediation occurred and facilities are reused; and

(g) where underground or buried piping and liquid storage and drain collection systems existed.

8.26 Information and data obtained during the characterisation process should be incorporated in the final decommissioning plan as appropriate.

### *Non-radiological characterisation*

8.27 Non-radiological hazards should be considered and evaluated during planning with regard to their potential impact on methods, processes and tasks for undertaking decommissioning and in particular on radiological protection of operators, the public and the environment.

### *Soil and sediment & surface and groundwater remediation*

8.28 During operations, the contamination of surface and subsurface soil, sediment, and ground and possibly surface waters, may occur and should be characterised and evaluated. Contamination may result from effluents; leakage from buildings, piping and liquid storage systems; incidents; leaching through evaporation ponds; and waste burial. Additional to the facility, characterisation and

remediation may be needed onsite and offsite if radioactive material has migrated in surface or groundwater.

8.29 Remediation of these modes may be required in order to meet the endpoint goal of restricted or unrestricted release of the facility and may involve treatment of soil, sediment or liquids that are contaminated with both radiological and non-radiological hazardous chemicals. Remediation actions may involve physical or chemical techniques necessary to remove the radiological contamination from the groundwater system, for example, pumping and chemical treatment or volatilisation processes.

8.30 If permitted by ARPANSA, remediation actions may be taken prior to the approval of the decommissioning plan. An example of when such remediation actions might be taken would be when concentrated areas of contamination are known.

8.31 Guidance on the remediation process can be found in the IAEA Safety Standards Series publications [19]Error! Reference source not found.

### *Evaluation of infrastructure*

8.32 The various SSCs and buildings should be evaluated for their suitability, condition and fitness for decommissioning and for ensuring safety during decommissioning based on the results of the safety assessment. The evaluation should be used for final decommissioning planning. The level and extent of facility evaluation depends on, for example:

(a) the proposed use, safety functions or requirements of the SSCs during decommissioning;

(b) condition of the SSCs;

(c) modifications needed for decommissioning e.g. additional floor and crane loading capability;

(d) extent of inspection and maintenance of SSCs; and

(e) end state of decommissioning e.g. reuse of building or structures versus demolition.

8.33 Assessment areas which should be covered include:

(a) evaluation of building structures and cranes for stability and loading capability;

(b) evaluation of structural integrity of the SSCs;

(c) availability and adequacy of systems supporting the SSCs e.g. alarm and communication systems, ventilation systems;

(d) adequacy and integrity of infrastructure required for decommissioning e.g. electrical supply, effluent drainage and transfer systems, waste storage suitability and capacity;

(e) processes and infrastructure interfaces with other facilities in the case of multi-facility sites; and

(f) facility modification and decommissioning infrastructure.

8.34 Depending on the strategy to be implemented, infrastructure should be established and/or modified to facilitate immediate dismantling or in some cases to prepare the facility for a safe enclosure period.

8.35 For immediate dismantling the main modifications may involve:

(a) modification or substitution of SSCs that are important for ensuring safety during decommissioning, such as filtration and ventilation systems;

(b) creation of buffer storage areas for equipment, materials and waste;

(c) establishing new access and transport routes for personnel and equipment to, and within, the facility;

(d) installation of additional equipment (e.g. handling and monitoring equipment); and

(e) modification of existing waste processing equipment or establishing new equipment.

8.36. For deferred dismantling and safe enclosure the main modifications may involve:

(a) establishing physical protection measures;

(b) establishing passive containment systems; and

(c) creating storage areas for equipment, materials and waste.

8.36 The management system in place during operation should be reviewed and revised to ensure that all equipment necessary for safety during decommissioning is periodically monitored to maintain its safety function and to detect any degradation. 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 for the extension of the period of its use.

8.37 As part of this exercise in reviewing the systems required for decommissioning, it is useful to identify systems that are not required to support the decommissioning strategy. As long there is no impact on other facilities on a multi-facility site, surveillance and maintenance carried out on these systems can cease.

### *Decommissioning tasks*

8.38 Decommissioning tasks that are typically conducted include decontamination, dismantling, demolition, clean-up and soil remediation in the vicinity of the facility. The objectives of these decommissioning tasks include:

(a) reduction of potential onsite and offsite hazards during decommissioning activities;

(b) reduction of exposure dose rates to permit manual or semi-remote dismantling and demolition;

(c) reclassification of waste to less hazardous categories;

(d) volume reduction of waste for disposal; and

(e) salvage of equipment, materials or premises permitting unrestricted use of the item.

8.39 Supporting tasks that were conducted during facility operation and that will continue during decommissioning could include waste processing, storage and disposal; environmental monitoring; surveillance and maintenance of equipment and systems.

### *Surveillance and maintenance of structures, systems and components (SSCs)*

8.40 Surveillance and maintenance of the SSCs designated as safety related for decommissioning, should be carried out from when operations cease until decommissioning is completed and during any period of deferred decommissioning.

8.41 If activities of decontamination and dismantling are deferred in part or in whole, safety should continue to be ensured through a proper surveillance and maintenance program. Under a deferred dismantling strategy, the surveillance and maintenance program might possibly be reduced during the period of deferral. If a facility is to be entombed a limited surveillance and maintenance program may still be necessary.

8.42 Before a facility is put into a period of deferral before dismantling the risk of potential incidents should be minimised. For example, spent fuel, bulk process radioactive material, and operational waste should be removed. Consideration should be given to removing, containing or immobilising any remaining loose contamination, where practicable. The following activities should continue to be performed and records of such activities should be kept:

(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; and

(e) maintenance of records about the surveillance and maintenance activities performed.

### *Selection and implementation of decommissioning techniques*

8.43 Decommissioning tasks typically include decontamination, dismantlement, and demolition. Many techniques have been developed that may be applicable to decommissioning. Suitable decommissioning techniques should be established as part of decommissioning planning and their applicability to the particular decommissioning tasks thoroughly evaluated before selection. Site or facility specific features may require particular techniques to be developed but the objective should be to select proven techniques that are commercially available. International exchanges of information and experience should be encouraged.

8.44 New decommissioning techniques should be justified and demonstrated as capable of obtaining the desired outcome from both a performance and safety perspective. In this case benefits can be taken from computer-based as well as physical mock-ups to select decommissioning techniques, to evaluate options, to aid in the design and to train personnel. Innovative techniques should be demonstrated in mock-up trials and other simulations prior to their use in decommissioning.

8.45 Systems, processes and components to which little attention has been given during operation or for which access is limited may have resulted in system degradation. Such systems present special consideration when decommissioning techniques are considered. Examples include liquid storage tanks and remote handling systems. Some possible problems associated with liquid storage tanks include difficulty in accessing, characterising, retrieving sludge and tank clean-up.

8.46 Before any decommissioning technique is selected an evaluation of its suitability should be conducted. The following factors may influence the suitability of the decommissioning techniques:

(a) cost–benefit analysis comparing the radiological benefits and waste management benefits of the decommissioning technique with the expected costs;

(b) potential impact on the workers and the environment for example giving preference to techniques that do not generate airborne radioactivity;

(c) types and properties (e.g. size, shape, contamination limits and accessibility) of the equipment and structures to be dismantled;

(d) decontamination factor and cutting rate likely to be achieved;

(e) compatibility of existing SSCs with decontamination solutions and processes to ensure they will not be degraded and become ineffective;

(f) impact on adjacent systems and structures and on other work in progress;

(g) methods available for controlling radiological and non-radiological hazardous materials;

(h) reliability of the dismantling equipment and tools and their simplicity to operate, decontaminate and maintain;

(i) availability of waste containers and the associated handling systems and routes for disposal; and

(j) time and schedule constraints.

8.47 Similar to the selection of decommissioning techniques, supporting tasks (including waste and materials management, storage and disposal; environmental monitoring; surveillance and maintenance of equipment and systems), should be continued from operation or implemented for decommissioning. These tasks should be thoroughly assessed before selection.

### *Decontamination and clean-up*

8.48 Decontamination covers the broad range of activities directed to the removal or reduction of radioactive contamination in or on materials, structures and equipment at a facility. Decontamination is usually performed using decontamination agents (e.g. liquid solutions, foam, gel, etc.) or physical removal of contaminated surfaces and components.

8.49 Decommissioning of a facility may be aided at certain stages by partial or total decontamination. Decontamination may be applied to internal or external surfaces of components and systems, structural surfaces and the tools employed in decommissioning. The process of decontamination can be conducted before, during or after dismantling.

8.50 The main objectives of decontamination include:

(a) reducing exposures during decommissioning activities;

(b) minimising the volume of waste and the categories of material to be classified or disposed of as solid radioactive waste; and

(c) increasing the opportunities for recycle and reuse of equipment, materials or premises.

8.51 Before any decontamination technique is selected an evaluation of its effectiveness and of the potential for reducing total exposure should be performed. SSCs should be assessed for compatibility with techniques, processes and agents that may be used during decontamination to ensure that their effectiveness will not be degraded during decontamination. The evaluation should include:

(a) probable radiation doses involved;

(b) decontamination factor likely to be achieved;

(c) cost–benefit analysis comparing the radiological benefits and waste management benefits of the decontamination effort with the expected costs;

(d) potential impact on the workers and the environment; and

(e) assessments of the primary and secondary wastes arising from the decontamination, including their treatment volumes, physical and chemical forms, and activity.

8.52 Consideration should be given to the compatibility of wastes generated during decontamination with existing systems for the handling, treatment, conditioning and disposal of wastes. Before waste is generated, adequate arrangements for its handling and management should be in place.

8.53 After dismantling of the process and supporting equipment clean-up of buildings may be necessary. A methodology must be developed and implemented to remove the contamination using appropriate processes and tools depending on the type of construction and objectives to be achieved. Clean-up of buildings may involve specific techniques to remove a surface or concrete layer by grinding or scarifying using pneumatic hammers or other industrial demolition equipment.

### *Dismantling*

8.54 There are many options available for dismantling, and their selection depends on the types and characteristics (e.g. contamination, activation, size, shape and accessibility) of the SSCs to be dismantled. Further information on these technologies as well as their advantages and disadvantages can be found in IAEA and OECD NEA publications [20].

8.55 Careful selection and pre-testing of the dismantling technology and procedures assists in minimising the decommissioning time, the volume of radioactive wastes and the dispersion of contamination; the optimisation of radiation exposure doses; and contributes to safety. Each dismantling task should be analysed to determine the most effective and safe method to perform it.

8.56 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 SSCs to be dismantled.

8.57 Dismantling activities by themselves may spread contamination. Cutting and demolishing (such as by abrasion or explosives) can result in the dispersion of radioactive dust. Consideration should be given to techniques to minimise the production of airborne radioactive material and implementing effective methods of its control such as using water sprays, controlling airflow and using filtration. Care should be exercised during demolition to ensure that contaminated material is segregated from non-contaminated material and non-radiological hazardous materials.

8.58 There are many techniques and methods available for dismantling (eg. in atmosphere or underwater cutting, remote or not, etc). Special tools and devices may be required during the dismantling activities. 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.

8.59 The applicant may consider the following:

(a) reliability of the dismantling equipment and its simplicity to operate, decontaminate and maintain;

(b) effects of dismantling task on adjacent systems and structures and on other work in progress;

(c) effective methods available for controlling airborne radionuclides and generated wastes;

(d) training requirements;

(e) designated waste management routes; and

(f) time required for dismantling.

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

8.61 Depending on the decommissioning end state demolition of the building structure may be required. 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.

## Waste and materials management

**Requirement 14: Radioactive Waste Management**

The licence holder must establish methods to safely manage all radioactive waste streams.

8.62 The aim of radioactive waste management is to effectively isolate the waste during the time when it has the potential to give unacceptably high radiation doses to people or to the environment.

8.63 Decommissioning invariably involves the generation of large amounts of radioactive wastes. In the course of decommissioning waste will be generated in forms that may be different from materials and wastes of the types routinely handled during the operational phase of a facility. Appropriate techniques for decontamination and dismantling should be applied and the volumes of wastes generated should be minimised. Systems and facilities must be available for managing the waste generated during decommissioning including storage and/or disposal facilities. It may be necessary to temporarily store dismantled material and/or radioactive waste during active decommissioning.

8.64 Materials should be reused or recycled to the extent practicable to minimise the amount of radioactive waste to be managed. Some waste may be suitable for disposal in normal land-fill sites while some materials such as steel and concrete may be suitable for recycling or reuse outside the nuclear industry.

8.65 Part of the materials and waste arising during the decommissioning process may be sufficiently low in activity concentration for regulatory control to be wholly or partly removed. Clearance, which is the removal of radioactive materials or radioactive objects within authorised practices from any further regulatory control, may be granted by ARPANSA for the release of material from the site [21].

8.66 The removal of regulatory controls will only occur after the licence holder has demonstrated compliance with the criteria established by ARPANSA. The waste management plan should identify the manner for segregating radiological, non-radiological and hazardous wastes and the manner in which material will be cleared and released from the site.

8.67 Clearance and removal of radioactive materials and objects from regulatory control is discussed further in Appendix III.

### *Waste Management Plan*

8.68 Radioactive Waste Management Plan must be submitted as part of plans and arrangements for managing safety. Regulatory Guide: Plans and Arrangements for Managing Safety describe the regulatory expectations for waste management [14].

8.69 The waste management plan which is part of the decommissioning plan should cover all anticipated waste and material categories. The plan could be based on the waste management plan for the operating facility with provisions for additional waste volumes and categories associated to decommissioning activities. Some of the waste categories may require new disposal end points. The plan should anticipate periods requiring the processing of high volumes of wastes and how to minimise any impacts on decommissioning activities or the operations of existing facilities at a multi-facility site or to optimise the waste management on such a site.

8.70 In managing the waste from decommissioning, several factors should be considered in the waste management plan including:

(a) origin, amount, category and nature of the waste that will be generated;

(b) minimisation of the waste;

(c) the disposal route for radioactive wastes and availability of (interim) storage and disposal facilities;

(d) free release of the dismantled material as appropriate;

(e) reuse of equipment, premises and recycling of materials;

(f) generation of secondary waste and its minimization;

(g) mixed waste and the presence of non-radiological hazardous materials, such as beryllium and asbestos;

(h) methods for treatment, conditioning, transport, storage and disposal;

(i) availability of treatment capacities;

(j) special transport and packaging requirements e.g. for activated components dismantling;

(k) tracking systems for the radioactive waste;

(l) traceability;

(m) compliance to the waste acceptance requirements for processing facilities and storage (e.g. fissile material content); and

(n) compliance to the waste acceptance criteria of disposal facilities.

### *Authorised discharges and environmental monitoring*

8.71 During decommissioning radioactive and non-radioactive effluent may be generated. Discharges of material to the environment must be authorised by the relevant Commonwealth and State regulatory bodies and appropriately monitored by the licence holder.

8.72 The regulatory authorisation and control of radioactive discharges to the atmospheric and aquatic environments is an aspect of radioactive materials management for operating nuclear reactors and radioisotope production facilities. Authorised discharges are also an aspect of radioactive materials management in the decommissioning phase.

8.73 Typically, controlled discharges of gaseous and particulate material containing radionuclides are made through stacks and controlled liquid discharges are made via pipelines into sewerage systems or surface water bodies. In general, during decommissioning, the expected discharges of effluents should be less than during operation of the facility but may be different in form and radionuclide composition

8.74 It is typical for effluent discharges to vary through different stages of decommissioning. For example, as decommissioning leads to a progressive removal of radiological hazards, decommissioning results in the progressive reduction of radioactive discharges. In some instances decommissioning activities might result in elevated discharges for a limited period. Hence, the discharge authorisation for decommissioning should be revised as appropriate. If the facility undergoing decommissioning is part of a site with other operating facilities then the discharge authorisations for the facility and the site should be reviewed and revised in light of decommissioning.

8.75 An important and essential element in the control of discharges is regular monitoring both at the source of the discharge and in the receiving environment to ensure protection of the public and the environment. Monitoring of discharge points such as stacks and pipes is an example of source monitoring.

8.76 Environmental monitoring provides information needed for the assessment of the radiation doses to critical groups of the population from the presence of radioactive material or radiation fields in the environment. Hence, unless an exemption is granted, the licence holder should establish and implement a program for monitoring the environment in the vicinity of the decommissioning site both onsite and offsite to assess the radiological impacts of radioactive releases on the environment. Guidance for developing and implementing an environmental monitoring program can be found in the IAEA Safety Standards Series publications [22].

8.77 Discharge authorisation requires discharge and environmental monitoring. Discharge points (such as stacks) used for effluent and environmental monitoring during the operational period may be used if sufficient in scope. If insufficient, appropriate substitutes should be made. Guidance for developing and implementing a source monitoring program and for setting discharge limits can be found in IAEA Safety Standards Series publications [23].

### *Physical protection and safeguards*

8.78 Appropriate physical protection for the facility, commensurate with the associated threat level at the time must be maintained throughout decommissioning [1]. The security plans and arrangements must be submitted to ARPANSA with the final decommissioning plan for approval.

8.79 The objective of the security plans and arrangements is to prevent unauthorised access to the facility, sabotage, damage, theft, loss or unauthorised use. The arrangements should include administrative and physical controls and barriers to ensure that control is not relinquished or improperly transferred.

8.80 If the facility contains materials subject to safeguards during decommissioning the licence holder must comply with ASNO requirements and international agreements. The licence holder should implement the necessary decommissioning activities in order to remove the need for the physical protection and safeguards requirements as soon as practicable.

Guidance on ARPANSA's expectations for security plans and arrangements can be found in Section 6 of Regulatory Guide: Plans and Arrangements for Managing Safety [14].

### Emergency preparedness

**Requirement 13: Emergency Planning**

The licence holder must establish and maintain emergency planning arrangements commensurate with the hazards and must report events significant to safety in accordance with regulatory requirements

8.81 An appropriate program for emergency planning must be established, described in the final decommissioning plan, and maintained throughout decommissioning. Such a program should be submitted to ARPANSA with the final decommissioning plan.

8.82 The licence holder must develop plans and arrangements for implementation in accordance with the emergency program. The plan should be based on an assessment of the consequences of reasonably foreseeable accidents during decommissioning and should be aimed at minimising radiological consequences and ensuring protection of on-site personnel, the public and the environment.

8.83 The organisations with roles in the emergency plan should ensure that procedures are prepared for implementation in accordance with the plan. The organisations should be prepared for such emergencies and adequate facilities and equipment should be available and maintained. Personnel should be trained in emergency procedures and consideration should be made for regular testing and updating of these procedures by conducting exercises periodically.

8.84 Guidance for emergency preparedness and response can be found in IAEA Safety Standards Series publications [24]. ARPANSA's expectations for emergency plans, procedures and preparedness can be found in Section 7 of Regulatory Guide: Plans and Arrangements for Managing Safety [14].

## 9. Completion of decommissioning and surrender of licence

**Requirement 13: Completion of Decommissioning Actions and Termination of Authorisation**

The licence holder must demonstrate that on completion of decommissioning actions the end state criteria as defined in the final decommissioning plan and any additional regulatory requirements have been met.

9.1 Before completing decommissioning the licence holder should address the matters that ARPANSA will consider when deciding whether to accept surrender of the facility licence and release the site for restricted or unrestricted use.

## Final inspection and radiological survey

9.2 On completion of decontamination and dismantling activities a final radiological survey of the facility must be performed.

9.3 Results of the final radiological survey should be compared with results of an earlier (pre-decommissioning) baseline radiological characterisation survey to demonstrate that: the decommissioning objectives in the final decommissioning plan have been achieved; the facility is in a safe state; and the facility meets ARPANSA's requirements and criteria for residual radioactivity allowing restricted or unrestricted release from regulatory control.

9.4 Design and implementation of the survey should be discussed with ARPANSA during the planning period for the survey. The licence holder should develop procedures that describe the approach to conducting the survey and the activities for demonstrating compliance with the release requirements and criteria. These procedures should be submitted to ARPANSA for review and approval.

9.5 The survey data should be documented in a final radiological survey report and submitted to ARPANSA for review and approval. The results of the survey will be a major portion of final decommissioning reporting.

9.6 An example of the content of the final radiological survey report is provided in Appendix IV.

## Documentation and record retention

9.7 After completion of all decommissioning activities, appropriate decommissioning reporting documents should be prepared to record in a comprehensive way what has been done during decommissioning and to demonstrate that the end state for the site or facility (in the approved final decommissioning plan) has been achieved. This documentation should be retained in the form and for the time period agreed with ARPANSA.

9.8 Appendix V provides an example of final decommissioning reporting documents. The key final decommissioning reporting documents that should be retained for future use are the (updated) final decommissioning plan and the final radiological survey report.

9.9 A final decommissioning report should summarise decommissioning undertaken; dismantling of the facility; waste management including clearance of radioactive materials or objects from regulatory control; the final status of the site at the time for release from regulatory control or for conversion to other (nuclear) use; and any remaining restrictions on the site. The final decommissioning documentation should show as far as practicable that all radioactive materials present at the beginning of decommissioning are accounted for and their ultimate destination is confirmed.

## Licence amendment or surrender and future site re-use

9.10 At a single facility site, the facility can be released from regulatory control after approval by ARPANSA. For a multi-facility site, the facility can be released from regulatory control or incorporated into another licensed facility.

### *Control of the facility released with restrictions*

9.11 Release of the site or facility from regulatory control may be achieved progressively over parts of the facility or site or with restrictions to ensure radiological protection of human health and the environment. To achieve compliance with the appropriate release criteria, restrictions may be necessary for the use of or access to parts of the facility or site.

9.12 Specific restrictions should be established as necessary to control the removal of material from the site or facility, if that material cannot be released from regulatory control; the potential uses of a site or facility; and potential radiation exposure pathways. Appropriate arrangements for continuing control including financial assurances must be in place and the responsibility for their development, implementation and maintenance must be assigned unambiguously to a legal organisation or institution. Arrangements for the controls and monitoring compliance with them must be in accordance with regulatory requirements and approved by ARPANSA.

9.13 A plan for ongoing control, maintenance and surveillance of any area released with restrictions should be prepared by the licence holder and approved by ARPANSA. Legal and financial arrangements should be made for implementation of the plan.

9.14 Interested parties should be informed of any restrictions on the site or facility and of the results of monitoring and surveillance.

9.15 For surrendering a facility licence and applying for release from regulatory control the applicant should refer to Regulatory Guide: Surrender of Facility Licence and Release from Regulatory Control [21]

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# Appendix I

## Factors influencing selection of a decommissioning strategy

To assist the development of decommissioning strategies, some of the factors affecting the selection of a decommissioning strategy are further described below.

Optimisation of radiological protection of workers, the public and the environment

A1. An important principle in selecting the decommissioning strategy is to ensure that the level of radiation protection for each source of radiation is optimised so that individual doses and collective doses are kept as low as reasonably achievable, economic and social factors being taken into account (ALARA). Radiation protection is considered to be optimised when the level of protection needed to further decrease individual or collective doses cannot be achieved without an unreasonable social or economic cost. This includes exposure of the public and the environment that might result from radioactive discharges via airborne and liquid effluents during decommissioning.

A2. In selecting a strategy to optimise radiation dose to occupational personnel, the public and environment, consideration should be given to:

(a) residual radiation at the commencement of decommissioning;

(b) timing of the start of decommissioning and the schedule and sequence in which decommissioning is carried out;

(c) available decommissioning technologies, techniques, expertise and services;

(d) the use of remote handling and tooling technology for large nuclear installations such as reactors and radioisotope production facilities;

(e) decontamination of structures, systems and components if necessary before decommissioning starts;

(f) the time that occupational personnel would need to spend in radiation zones. Training with inactive mock-ups and models can improve efficiency;

(g) the availability of and access to radiation protection services and equipment;

(h) the need for fixed or portable shielding between the radiation source and the occupational personnel; and

(i) the availability of waste handling and storage facilities and services to avoid undue accumulation of waste and the spread of contamination by clearing away waste as it is produced.

### *Compliance with the legal framework*

A3 Decommissioning of a nuclear installation can only be undertaken in accordance with the regulatory framework. This framework should be considered when selecting a strategy and planning for decommissioning.

### *Type of nuclear installation, interdependencies with other facilities or infrastructure located at the same site*

A4. The type of controlled facility (e.g. nuclear research reactor, radioisotope production facility or research facility), its past functions, operational history and the extent of clean-up needed (e.g. soil/sediment and surface and groundwater) will have major impacts on the strategy selected.

A5. These facilities can be categorised by residual radionuclides according to the operations that were performed, the size and location of the facility and its relationship with other facilities on the site. The specific characteristics of each facility will strongly influence the selection of the decommissioning strategy.

A6. Furthermore, in selecting a strategy consideration should be given to non-safety related matters such as reuse or recycling of materials as opposed to disposal. Where relevant, safeguards related issues should also be considered in optimising both safety and resources in the decision-making process for the optimal decommissioning strategy.

A7. The extent of contamination in a facility will depend greatly on past operational practices, the age and type of facility. The period of design and construction will have influenced the types of materials used in construction which in turn affects the level and type of residual radioactivity in the facility. The design of the facility particularly whether decommissioning was considered in its design will affect the ease of decommissioning and choice of strategy.

A8. Account should be taken of the characteristics of the site where the facility is located. At a multi-facility site, the capabilities of and synergies with other facilities on the site may lead to better safety approaches for decommissioning although the decommissioning of a facility should not be allowed to adversely affect safety of the other facilities. The capabilities of the other infrastructure and facilities (such as transport, handling, treatment and storage of radioactive waste) may be used as well as the capabilities and experience of the site's personnel. These considerations may affect the options available for selection of a strategy.

A9. Additionally, the facility's location within a multi-facility site may pose unique challenges to decommissioning. For example, a research reactor could be located in a research establishment or a radioisotope production facility might be located in a hospital. As a consequence it may be beneficial for example to place the oldest facilities into a deferred dismantling state until the remaining facilities are closer to permanent shutdown.

### *Proposed reuse and desired end state*

A10. Alternatively, the potential demand for reuse of the site either for restricted or unrestricted use is an important consideration for the selection of a decommissioning strategy. The desired end state could be release from ARPANSA control, allowing new use of the all or part of the site or existing building structures. This might lead to a preference for selecting a strategy of immediate or early dismantling of part or all of the facility and/or decontamination of the existing building structure to a level suitable for new use.

A11. Reuse of the site is generally not compatible with entombment of a facility.

### *Physical status of the facility*

A12. The integrity and conditions of the buildings and SSCs should be considered when selecting a decommissioning strategy. The length of time and work necessary to maintain and secure buildings and SSCs in order to preserve safe enclosure will influence the choice of decommissioning strategy and timing.

### *Facility radiological condition*

A13. The types of radionuclides used at a facility can have a major impact on the exposure that workers, public and environment may receive during the decontamination and dismantling activities. Facilities that contain different levels of activity and contamination may pose different levels of risk of radiation exposure to workers, the public and the environment.

### *Availability of expertise, technologies and infrastructure*

A14. The availability and use of institutional knowledge such as documentation of the operational history and/or retention and use of key personnel familiar with site-specific conditions should be considered in choosing a decommissioning strategy. Such documentation could assist in planning and undertaking decommissioning and may help to reduce problems associated with loss of corporate memory. A good system of recordkeeping for this purpose is important.

A15. Similarly, although the decommissioning process and the former operating phase require different human skills, staff with knowledge of the operation, maintenance, repairs, modifications and history of the operating facility could be useful for planning and undertaking decommissioning and help with knowledge transfer. This could also decrease the potential for events such as industrial accidents or undue exposures.

A16. An immediate dismantling strategy allows for direct use of operating personnel in dismantling activities. A consequence of selecting a deferred dismantling strategy could be that the personnel staff conducting final dismantling may have to be newly trained or experienced contractors engaged.

A17. In the case of a multi-facility site or facilities on various sites it could be useful to take advantage of the learning experience gained from decommissioning of the first facility by re-deploying experienced personnel or using the capabilities and personnel of one facility for decommissioning another. Benefits could be also realised by sharing decommissioning infrastructure, equipment and tools between facilities.

A18. Movement of workforce and equipment from one decommissioning project to the next can permit more effective decommissioning and a more efficient use of personnel and equipment and are factors for consideration in deciding the preferred decommissioning strategy.

A19. The techniques needed for dismantling activated and contaminated facilities are common to all decommissioning strategies. Although there will be differences in the application of dismantling techniques used for immediate and deferred dismantling strategies, the techniques chosen will be the same in principle. There are few advantages to be gained from waiting for technology to progress because most of the techniques needed already exist and are adequate. Remote dismantling techniques are less likely to be required after a period of safe enclosure.

### *Environmental and socioeconomic impact*

A20. Because of the potential for deterioration of the facility or SSCs over time, the deferred dismantling strategy might result in the need for refurbishment or replacement investment and work being made before beginning the dismantling work. Deferred dismantlement requires a commitment to the prevention of environmental contamination by control during the safe enclosure period and by adequate building management and inspection. A strategy of immediate dismantling strategy may pose a lower risk of environmental contamination due to building deterioration.

A21. When the impact on the local economy is an important issue, immediate dismantling might be the preferred strategy because this will reduce the negative social effect while continuing to stimulate the local economy and provide employment for the local workforce.

A22. For most facilities, the number of employees and local support needed during decommissioning will generally be less than the number employed and local support during facility operations. If deferred dismantling is selected as the strategy, the workforce will be reduced considerably during the enclosure period and then may increase again during later dismantling.

### *Waste management*

A23. Aspects of waste generation and waste management can have an impact on the selection of a decommissioning strategy. Some of the most important aspects are:

(a) overall national waste management strategy (e.g. one that prefers clearance);

(b) types, categories and amount of waste arising during decommissioning;

(c) availability of waste treatment facilities or infrastructure for all types of radioactive waste;

(d) infrastructure for the transport of radioactive materials;

(e) availability of storage capacity; and

(f) availability of final disposal capacity.

A24. In the absence of waste treatment facilities or infrastructure, interim storage capacities or disposal capacity, the preferred strategy decommissioning is likely to be deferred dismantling. In the case of no existing disposal capacity but external or on-site waste treatment and storage facilities, immediate dismantling is a viable decommissioning strategy. If disposal capacity is available then both immediate dismantling and deferred dismantling are viable strategies.

# Appendix II

## General content of a final decommissioning plan

The following list of elements of decommissioning plans has been developed based on several reference publications [1-3]. Some of these elements such as safety assessment and environmental impact assessment are usually incorporated into the decommissioning plan by reference and a short summary provided in the decommissioning plan. Following a graded approach, the level of detail will depend on the complexity of the decommissioning activity.

1. Introduction

2. Facility description
   - 2.1. Site location and description of the site and facility
   - 2.2. Building, systems and equipment description
   - 2.3. Facility and site radiological characterizations and surveys
   - 2.4. Site and facility operational history and historical developments including site releases, incidents and corrective actions

3. Decommissioning strategy
   - 3.1. Objectives
   - 3.2. Decommissioning strategies
   - 3.3. Selection and justification of preferred strategy

4. Decommissioning management
   - 4.1. Management system
   - 4.2. Safety management
   - 4.3. Organizational and administrative controls
   - 4.4. Staffing, qualification and training
   - 4.5. Project management
   - 4.6. Quality management
   - 4.7. Documentation and recordkeeping
   - 4.8. Contractors involvement
   - 4.9. Decommissioning schedule
   - 4.10. Specific decommissioning issues such as coordination with multiple competent authorities, stakeholder involvement

5. Conduct of decommissioning
   - 5.1. Contaminated structures, systems and equipment
   - 5.2. Surface and subsurface soil and sediment
   - 5.3. Ground and surface water
   - 5.4. Decontamination and dismantling techniques and technologies

- 5.5. Decommissioning release criteria
- 5.6. Surveillance and maintenance

6. Waste management program
   - 6.1. Identification of waste streams
   - 6.2. Solid radioactive waste
   - 6.3. Liquid radioactive waste
   - 6.4. Waste containing both radionuclides and other hazardous material
   - 6.5. Clearance

7. Cost estimate

8. Radiation protection

9. Safety assessment
   - 9.1. Identification of hazards and initiating events
   - 9.2. Evaluation of occupational and public exposure during decommissioning
   - 9.3. Evaluation of potential exposure

10. Environmental impact assessment

11. Emergency planning

12. Physical protection and safeguards

13. Final radiological survey design
    - 13.1. Map or drawing of the area to be surveyed
    - 13.2. Sampling parameters
    - 13.3. Background/baseline levels
    - 13.4. Types of equipment, instruments, techniques and procedures
    - 13.5. Methodology for evaluating survey results
    - 13.6. Demonstration of compliance with the release criteria
    - 13.7. Ongoing restrictions arising
    - 13.8. Records to be maintained

14. Summary

***References***

[II-1] International Atomic Energy Agency, Decommissioning of Nuclear Facilities, IAEA Draft Safety Guide DS452, IAEA, Vienna (2017).

[II-2] International Atomic Energy Agency, Standard Format and Content for Safety Related Decommissioning Documents, IAEA Safety Report No. 45, IAEA, Vienna (2005).

[II-3] Nuclear Energy Agency, Achieving the Goals of the Decommissioning Safety Case, Working Party on Decommissioning and Dismantling (WPDD) 3, (2005).

# Appendix III

## Exemptions, clearance, removal from regulatory control and surrender of a facility licence

This appendix provides guidance to assist the determination of whether ARPANSA should accept exemption or clearance of radioactive material or radioactive objects from regulatory control during decommissioning; or release a facility from regulatory control, following decommissioning, and surrender of a facility licence. A licence holder seeking such approvals should ensure the principles included in this appendix are covered in their submission to ARPANSA.

Regulatory control is any form of control or regulation applied to nuclear installations and radiation activities by ARPANSA for reasons related to nuclear safety, radiation protection or nuclear security [1]. Regulatory control is generally exercised through facility or source licences.

Exemption is determination by ARPANSA that radioactive materials or radioactive objects, or radiation activity, need not be subject to all or some aspects of regulatory control [1].

Clearance is the removal of radioactive materials or radioactive objects within authorised (licensed) facility or activity from any further regulatory control [1, 2].

While exemption is used as part of a process to determine the nature and extent of application of the system of regulatory control, clearance is intended to establish which material under regulatory control can be removed from this control. As with exemption, a clearance may be granted by ARPANSA for the release of material from a facility or activity.

## General Criteria

It is generally accepted that regulatory control is not warranted if the radiation risks arising from a radiation source or activity, cleared material, or decommissioned facility are sufficiently low.

Radiation risks are considered to be sufficiently low provided that under all foreseeable circumstances the effective dose expected to be incurred by any member of the public is in the order of 10 µSv or less per year. For low probability scenarios, the effective dose should not exceed 1 mSv [1]. In regard to international best practice (IBP) some regulatory bodies use 10 µSv/yr as equating to sufficiently low risk.

## Values of Activity and Concentration for Exemption and Clearance

Various scenarios of foreseeable circumstances have been analysed to determine maximum values of activity and concentration of radionuclides that are consistent with these criteria [3].

Activity and concentration limits for the exemption of moderate amounts of materials (up to one tonne) and mixtures of materials are given in Schedule 2 Part 2 of the ARPANS Regulations [4]. For the exemption and clearance of bulk amounts of materials, concentration limits are given in Schedule I Table I-1 of IAEA GSR Part 3 [1].

IAEA advice on the application of exemption principles is provided in IAEA RS-G-1.7 [2].

Naturally occurring radionuclides are excluded using the descriptions of exempt dealings in Schedule 2 Part 1 of the ARPANS Regulations [4] and the Natural Origin Exemption Levels where 40K is 10 Bq/g and 1 Bq/g is used for all other radionuclides of natural origin. For noble gases, the exemption levels should be those provided in Schedule 2 Part 2 of the ARPANS Regulations. For a mixture of both natural and artificial origin nuclides, both of these conditions for mixtures apply.

## Release of a controlled facility from regulatory control

Surrender of a facility licence and release from regulatory control is discussed in references [5] and [6]. The guiding principles for release of a controlled facility from regulatory control are:

a) The remaining structures, systems components and the environment at the location of the facility must no longer contain radioactive material unless the material(s) are exempt from regulatory control.

b) All materials containing non-exempt radionuclides must be transferred to an appropriate licence or disposed of using an approved method.

c) The risk from radioactivity levels at the facility location which are associated with the facility (i.e. above natural background) should be sufficiently low.

ARPANSA must be satisfied that the licence holder has adequately demonstrated by analysis or measurement or both that radionuclide total activities or concentrations are below the exemption levels. Consideration should be given to commissioning independent assessment or measurement.

Before a licence may be surrendered the operating organisation must account for the full inventory of non-exempt radioactive material arising from the decommissioning process and its transfer or disposal. Additionally, the licence holder must demonstrate that all non-exempt waste is managed appropriately. Regulatory guidance on the disposal of radioactive material is given in reference [7].

ARPANSA must be satisfied that risks from any residual radioactivity levels resulting from the decommissioned facility are sufficiently low, taking account of any restrictions on its future use. An application to surrender a licence should demonstrate that the dose expected to be incurred by any member of the public is in the order of 10μSv per year or less. Justification should be provided by the operating organisation to deviate from this objective.

***References***


[III-1] European Commission, Food And Agriculture Organization Of The United Nations, International Atomic Energy Agency, International Labour Organization, OECD Nuclear Energy Agency, Pan American Health Organization, United Nations Environment Programme, World Health Organization, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards, IAEA Safety Standards Series No. GSR Part 3, IAEA, Vienna (2014).

[III-2] International Atomic Energy Agency, Safety Standards, Application of the Concepts of Exclusion, Exemption and Clearance, IAEA Safety Guide RS-G-1.7, 2004.

[III-3] Commission of European Communities, Principles and Methods for Establishing Concentrations and Quantities (Exemption Values) below which Reporting is not Required in the European Directive – XI-028/93, 1993.

[III-4] Australian Radiation Protection and Nuclear Safety Regulations, 1999.

[III-5] IAEA Safety Standards – Release of Sites from Regulatory Control on Termination of Practices - IAEA Safety Guide WS-G-5.1, 2006.

[III-6] Australian Radiation Protection and Nuclear Safety Agency: Regulatory Guide: Surrender of a Facility Licence and Release from Regulatory Control (2014).

[III-7] Australian Radiation Protection and Nuclear Safety Agency, Disposal of Controlled apparatus and Controlled Material OS-RC-SUP-252A, 2013.

# Appendix IV

## Final radiological survey report

### *IV-I: Example of the contents*

The final radiological survey report presents the final conditions at the facility and site at the conclusion of the physical decommissioning activities. The report is a part of the final decommissioning reporting documentation and includes:

1. Final Radiological Survey Plan
   - (a) Location of the facility
   - (b) Type of facility
   - (c) Site and facility description such as: site; facilities; buildings; any remaining subsurface structures included in the final survey; and facilities remaining in operations and their interdependencies
   - (d) Survey design justification based on:
     - i. Initial site radiological characterization including background levels
     - ii. Initial facility radiological characterization, including any additional characterisation needed
     - iii. Identification of potential sources or areas of contamination
     - iv. Locations including significant ratios between radionuclides (radiological characterization)
     - v. Survey areas including their radiation classification
   - (e) Survey design details including:
     - i. Types of surveys to be conducted
     - ii. Type of instrumentation to be used, their sensitivity and techniques for use
     - iii. Sampling plan (e.g., map, type and number of measurements and analyses to be performed)
     - iv. Procedures for recording measured data and analytical results
     - v. Procedures for evaluation of data and results, comparison with established guidelines, and reporting consistent with regulatory framework
     - vi. Quality assurance
2. Conduct of Survey and Survey Results
   - (a) Summary of survey including changes from the Final Radiological Survey Plan
   - (b) Sampling performed (e.g., map, type and number of measurements and analyses performed)
   - (c) Measured data and analytical results

(d) Data evaluation, comparison with previous radiological surveys and established guidelines and release criteria, and reporting consistent with regulatory framework

(e) Quality assurance

3. Summary and Conclusion

(a) Concise description of the final radiological situation at the facility including any areas that were not surveyed

(b) Identification of all areas, systems and components that can be released for unrestricted use

(c) Identification of all areas, systems and components that can be released with restrictions

(d) Description of any institutional controls that will be required for areas that can not be released, including overview drawings and maps

***References***

1. International Atomic Energy Agency, Standard Format and Content for Safety Related Decommissioning Documents, IAEA Safety Report No. 45, IAEA, Vienna (2005).

# Appendix V

## Final decommissioning reporting documents

### *V-I Example of contents*

These final decommissioning reporting documents could include:

1. Final decommissioning plan, updates and any related authorisations

   (including decommissioning safety assessments and decommissioning environmental impact assessments and their updates)

2. Final radiological survey report

   (for facilities and site leading to release with restricted use, list of designated structures, areas and equipment and description of restrictions and eventual removal of controls, if applicable)

3. Radiation exposure documentation

4. Waste management documentation