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IAEA PROVISIONAL CODE OF PRACTICE ON MANAGEMENT OF RADIOACTIVE WASTE FROM NUCLEAR POWER PLANTS

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FOREWORD

The demand for energy is continually growing, both in the developed and the developing countries. Traditional sources of energy such as oil and gas will probably be exhausted within a few decades, and present world-wide energy demands are already overstraining present capacity. Of the new sources nuclear energy, with its proven technology, is the most significant single reliable source available for closing the energy gap that is likely, according to the experts, to be upon us by the turn of the century.

At present, more than 250 power reactors are in operation throughout the world, approximately 250 more are under construction or planned. The nuclear power reactors in operation represent more than 2000 accumulated years of operating experience and supply about 8% of the world's electricity.

Since its inception the nuclear energy industry has maintained a safety record second to none. Recognizing the importance of this aspect of nuclear power and wishing to ensure the continuation of this record, the International Atomic Energy Agency established a wide-ranging programme to provide the Member States with guidance on the many aspects of safety and technology associated with thermal neutron nuclear power reactors and the associated fuel cycle facilities, including those for management of radioactive wastes.

An on-going programme for documentation of the safety aspects for power reactors involves the preparation and publication of about 50 books in the form of Codes of Practice and Safety Guides. This programme has become known as the NUSS programme (the letters being the acronym for Nuclear Safety Standards). The publications are being produced in the Agency's Safety Series, and each one will be made available in separate English, French, Russian and Spanish versions.

They will be revised as necessary in the light of experience to keep their contents up to date. The Codes of Practice issued under the NUSS programme are:

Governmental Organization for the Regulation of Nuclear Power Plants, IAEA Safety Series No. 50-C-G (1978)

Safety in Nuclear Power Plant Siting, IAEA Safety Series No. 50-C-S (1978)

Design for Safety of Nuclear Power Plants, IAEA Safety Series No. 50-C-D (1978)

Safety on Nuclear Power Plant Operation, including Commissioning and Decommissioning, IAEA Safety Series No. 50-C-O (1978)

Quality Assurance for Safety in Nuclear Power Plants, IAEA Safety Series No. 50-C-QA (1978)

The Codes of Practice and Safety Guides are recommendations issued by the Agency for use by Member States in the context of their own nuclear safety requirements. A Member State wishing to enter into an agreement with the Agency for the Agency's assistance in connection with the siting, construction, commissioning, operation or decommissioning of a nuclear power plant will be required to follow those parts of the Codes of Practice and Safety Guides that pertain to the activities covered by the agreement. However, it is recognized that the final decisions and legal responsibilities in any licensing procedures always rest with the Member State.

The NUSS publications presuppose a single national framework within which the various parties such as the regulatory body, the applicant/licensee and the supplier or manufacturer, perform their tasks. Where more than one Member State is involved, however, it is understood that certain modifications to the procedures described may be necessary in accordance with national practice and with the relevant agreements concluded between the States and between the various organizations.

The Codes and Guides are written in a form to enable a Member State, should it so decide, to make the contents of such documents directly applicable to activities under its jurisdiction. Therefore, consistent with accepted practice for codes and guides, "shall" and "should" are used to distinguish for the potential user between a firm requirement and a desirable option.

The publication presented here is one of a series* of Codes of Practice and Safety Guides specifically on the management of radioactive wastes from the various principal facilities in the nuclear fuel cycle. These waste management publications will be prepared on a time scale appropriate for the status of technologies their breadth of use, and the need for a specific Code of Practice. They will be consistent with and closely integrated with the above NUSS Codes of Practice as well as comparable publications regarding radiological safety and transport of radioactive materials:

Basic Safety Standards for Radiation Protection, IAEA Safety Series No. 9 (1982)

Principles for Establishing Limits for the Release of Radioactive Materials into the Environment, IAEA Safety Series No. 45 (1978)

Regulations for the Safe Transport of Radioactive Materials, 1973 Revised Edition (As amended) (1979)

The waste management Codes of Practice and Safety Guides will be supported by an extensive series of technical reports; listed at the end of this publication are those directly relevant to waste management at nuclear power plants.

Based on information obtained from various Member States and collated by the Secretariat, the first draft of this publication was prepared by a consultant working in Vienna in June 1981; it was

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* The first in the series is "Management of Wastes from the Mining and Milling of Uranium and Thorium Ores" IAEA Safety Series No. 44 (1976) (Under revision)

subsequently revised by five consultants meeting from 14 to 18 December 1981, and then reviewed by an Advisory Group meeting held in Vienna from 10 to 14 May 1982. Finally, the draft was completed by the Secretariat and published in its present form as an IAEA-TECDOC with a goal of obtaining a broad distribution and receiving comments on it from a considerable number of Member States, besides the Advisory Group participants. After receiving these comments, the Code will be revised once more by the Secretariat and will be submitted for review by a second waste management Advisory Group meeting in June 1983. When changes and additions, based on the reviews by these groups, have been completed, the draft will be transmitted to the Director General, who will submit it, as and when appropriate, to the Board of Governors for approval before final publication.

The Safety Guides to be issued will describe and make available to Member States acceptable methods of implementing specific parts of this Code of Practice. Methods and solutions varying from those set out in these Guides may be acceptable, if they provide at least comparable assurance that radioactive wastes can be managed without undue risk to the health and safety of the general public and site personnel. Although this Code of Practice and the Safety Guides establish an essential basis for safety, they may not be sufficient or entirely applicable. Other safety and technical documents published by the Agency should be consulted as necessary.

In some cases, in response to particular circumstances, additional requirements may need to be met. Moreover, there will be special aspects which have to be assessed by experts on a case-by-case basis.

Physical security of fissile and radioactive materials and of a nuclear power plant as a whole is mentioned in the NUSS programme Codes of Practice, where appropriate, but is not treated in detail. Non-radiological aspects of industrial safety and environmental protection are not explicitly considered.

The task of ensuring an adequate and safe supply of energy for coming generations, and thereby contributing to their well-being and standard of life, is a matter of concern to us all. It is hoped that the publication presented here, together with the others being produced under the aegis of the waste management programme, the NUSS programme and other safety-related programmes will be of use in this task.

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1. INTRODUCTION

1.1 Purpose

1.1.1 This Code of Practice defines the minimum requirements for operations and design of structures, systems and components important for management of wastes from thermal nuclear power plants. It emphasizes what safety requirements shall be met rather than specifies how these requirements can be met; the latter aspect is covered in Safety Guides.

1.1.2 The Code is addressed to senior management staff in regulatory authorities and implementing organizations designing, manufacturing and operating waste management systems, particularly in Member States that are in the early stage of developing nuclear power programmes.

1.1.3 The Code is intended to be used in conjunction with the Agency's other Safety Standards, Guides and Technical Publications dealing with the topics of safe operation of nuclear power plants, environmental protection, radiological safety and waste management practices. The documents listed at the end of this document will be of assistance in implementing the Code.

1.2 Scope

1.2.1 The Code defines the need for a Government to assume responsibility for regulating waste management practices in conjunction with the regulation of a nuclear power plant. The Code does not prejudge the organization of the regulatory authority, which may differ from one Member State to another, and may involve more than one body. Similarly, the Code does

not deal specifically with the functions of a regulatory authority responsible for such matters, although it may be of value to Member States in providing a basis for consideration of such functions.

1.2.2 The Code deals with the entire management system for all wastes from nuclear power plants embodying thermal reactors including PWR, BWR, HWR and HTGR technologies. Topics included are:* design, normal and abnormal operation, and regulation of management systems for gaseous, liquid and solid wastes, including decommissioning wastes.

1.2.3 The Code includes measures to be taken with regard to the wastes arising from spent fuel management at nuclear power plants. However, the options for further management of spent fuel are only outlined since it is the subject of decisions by individual Member States. The Code does not require that an option(s) be decided upon prior to construction or operation of a nuclear power plant.

2. GENERAL CRITERIA

2.1 Overall objective

The overall objective of waste management shall be to manage radioactive waste materials in a manner which prevents any unacceptable detriment to man and the environment. Thus the basic criteria against which to judge the acceptability of waste management facilities are radiological and environmental protection criteria. Although such facilities may differ widely, the same basic criteria should be applied when deciding on the acceptability of any facility.

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* The order in which the following items are stated is not intended as a recommendation of the order in which a Member State should undertake to implement them.

2.2 Radiological protection

The fundamental principle of radiological protection is that the risks associated with practices involving the radiation exposure of man should be kept to acceptable levels. This principle underlies the recommendations of the International Commission on Radiological Protection (ICRP) and in particular forms the basis for the ICRP system of dose limitation. This system has been incorporated in the IAEA Basic Safety Standards for Radiation Protection and has been accepted by many national authorities.

The main features of the ICRP system of dose limitation are:

(1) Justification

No practice involving radiation shall be adopted unless its introduction produces a positive net benefit. In waste management this principle is not applicable by itself; it must take into account the benefits derived from the activity by which the waste is generated, which in this case is the generation of nuclear power.

(2) Optimization

All radiation exposures shall be kept as low as reasonably achievable, (ALARA), economic and social factors being taken into account. Safety and regulatory requirements related to the power plant and aspects of storage, transport and disposal of wastes and effluents are considerations which are involved in this optimisation. In practice, application of the optimisation requirements is not straightforward because it must take account of exposures delivered in the distant future after the practice which produced the waste has been terminated.

(3) Dose Limits

The dose equivalent to individuals from all practices shall not exceed the appropriate dose limits set by the regulatory authority. This requirement is to be understood as a further constraint for optimization in order to ensure that low collective doses are not achieved at the expense of high individual doses. Therefore radiation exposure of plant personnel and the general public shall be limited, through controls on the direct exposure of personnel and releases of radioactive materials in effluents.

2.3 Environmental protection

Although protection of the environment from radiological effects is usually achieved while protecting man, some aspects of waste management involve operations which will have other effects on the environment. Potential effects include: constraints on the use of land and mineral resources, pollution of surface and underground water supplies, limitation of access to areas of particular environmental interest. These effects shall be considered in siting and designing waste management systems.

3. ADMINISTRATIVE AND LEGAL ASPECTS

3.1 Organization and responsibility

3.1.1 The general requirements on governmental organization for the regulation of nuclear power plants as described in the IAEA Code of Practice Safety Series 50-C-G are applicable to the regulation of waste management at the nuclear power plant. The roles and responsibilities of implementing organizations responsible for the various components of waste management shall be clearly defined at the Preliminary Safety Analysis Report (PSAR) stage, or some such equivalent stage.

3.1.2 It is, however, to be recognized that some parts of waste management (e.g., off-site disposal of the waste and the associated transport) may be beyond the termination of plant operation and that the activity of some of the waste outlasts the operational period by a considerable time. Decisions on the responsibilities for implementation of the post-operational waste management actions and control of the wastes shall be taken, and agreed at the appropriate governmental level, before initiation of the licensed plant operation.

3.1.3 The appropriate organizations shall define as soon as possible the requirements in relation to disposal options, since these requirements influence the treatment of wastes.

3.2 Role and responsibilities of an Implementing Organization

An Implementing Organization shall be responsible for conforming to the regulations for the design, construction and safe operation of waste management facilities.

In regard to his own function, which may relate to only certain items below, an Implementing Organization shall:

(1) Make a safety assessment of waste management activities

(2) Develop and submit proposals to the regulatory authority regarding the quantities of radionuclides to be discharged as effluents and the methods and procedures for monitoring and controlling such discharges

(3) Provide to the regulatory authority such design and construction documentation for processing, transporting, storing and disposing of radioactive waste as is required for demonstration of compliance with its regulations

(4) Prepare and maintain operating and maintenance instructions and train the operating and maintenance personnel in their duties

(5) Perform conditioning of wastes in accordance with a quality assurance programme approved by the relevant authority

(6) Monitor and keep records of effluents and provide to the appropriate regulatory authority periodical reports at such intervals as are required. In the event of an accident or mal-function make a prompt report.

(7) Maintain records of waste inventories for storage, transport and disposal.

3.3 Role and responsibilities of the regulatory authority

It is the responsibility of the regulatory authority to:

(1) Develop regulations and criteria for waste management

(2) Review and judge safety assessments of the waste management facilities in the context of the regulations and criteria

(3) Prescribe to the environment limits for discharge of radionuclides

(4) Audit for compliance with regulations and criteria by inspection of the radioactive waste management facilities, operations and records

(5) Enforce necessary corrective actions in case of noncompliance with regulations and criteria

(6) Provide a format for the periodic reports that it requires.

3.4 Financial and institutional aspects

Some parts of the management of radioactive waste from nuclear power plants, e.g., surveillance and maintenance of a waste repository, will continue after termination of the operation of the facility. Plans for such post-operational activities shall be established in agreement with the regulatory authority at such time as the authority requires as a base for decisions on their schedule of implementation and financing.

4. DESIGN OF WASTE MANAGEMENT FACILITIES

4.1 Design Objectives

The design of the waste management facilities shall provide for:

(1) Minimization of waste arisings within the overall power plant design; economic considerations being taken into account

(2) The safe collection, treatment, conditioning, storage, transport and disposal of all radioactive wastes arising from the operation of the plant in such a manner as to achieve the objectives set out in Section 2.

4.2 Design considerations

4.2.1 On-site waste management shall be considered as an integral part of nuclear power plant design and reference should be made to IAEA Code of Practice Safety Series 50-C-D where applicable to the design of radioactive waste treatment systems.

4.2.2 Radioactive wastes arising from a nuclear power plant shall be managed in a systematic way taking into consideration safety and regulatory requirements, economic consideration and aspects of storage, transport and disposal of wastes and effluents.

4.2.3 In the design of waste management facilities consideration shall be given to:

(1) Processing of wastes to ensure efficient storage and handling and limit the volumes requiring disposal

(2) Treatment of the wastes into forms in compliance with requirements for handling, transport, storage and disposal

(3) Technical feasibility and operating experience of alternative treatment and conditioning processes

(4) The origin and physico-chemical nature of the wastes to be treated

(5) Segregation of wastes into appropriate categories for subsequent treatment

(6) The effectiveness and reliability of treatment or conditioning processes to be applied

(7) Provision for adequate storage and treatment capacity for routine operation, shutdown and maintenance periods. Additionally storage capacity should be provided for unplanned events.

(8) Characteristics of the site and its environment to evaluate the potential impacts of any discharges during normal or emergency situations.

(9) Ensure that the pipework, valves, pumps and other components have a high degree of integrity

(10) Provision for monitoring and inspection

(11) Provision of containment basins and sumps with adequate equipment to control leakage

(12) Provision for representative process sampling

(13) System reliability and maintenance

(14) The possibility of connecting emergency waste treatment equipment to the existing facilities

(15) Future decommissioning operations.

4.3 Radioactive waste arisings and treatment

The type and nature of radioactive waste varies appreciably from power plant to power plant and are described in IAEA Technical Reports Series 198 together with typical examples of processing arrangements.

4.3.1 Collection and treatment of gaseous wastes

4.3.1.1 Where appropriate, gaseous waste shall be collected into a single common system to facilitate treatment, monitoring and control of release.

4.3.1.2 In the design of the treatment facilities attention should be paid to the operating temperature, removal efficiency, pressure drop, leak tightness, maintenance, fire resistance and hydrogen explosion. Standard methods for filter testing should be applied to assure that filters are properly installed and maintain appropriate removal efficiencies.

4.3.1.3 Where charcoal beds are employed in the treatment system, design aspects of particular importance which should be considered in order to maintain their efficiency are:

(1) moisture and particulate content

(2) operating temperature

(3) maintenance of gas purity to prevent 'poisoning' of the absorber

(4) provision of periodic testing facilities

4.3.2 Collection, storage and treatment of liquid wastes

Design of liquid waste management facilities shall:

(1) Choose liquid processes (e.g. filtration, evaporation, ion-exchange) which represent suitable treatment for each category of liquid waste with consideration given to handling, storage, transport and disposal and process reliability and industrial experience

(2) Reduce the potential for particulate deposition in piping

(3) Provide adequate volume for any liquid overflows or leakages and appropriate leak detection

(4) Control the selection and loading of ion exchange media to avoid degradation of organic materials and generation of combustible gases

(5) Provide for direct immobilization of quantities of liquid waste not suitable for treatment by other methods.

4.3.3 Treatment and conditioning of solid wastes

4.3.3.1 Treatment techniques (e.g. compaction, shredding, fragmentation, decontamination, incineration and drying) and conditioning techniques (e.g. immobilization and packaging), shall be considered in relation to the provision of an optimized waste management system.

4.3.3.2 The selection of a particular process should take into account the following considerations:

(1) Physical and chemical nature of the waste

(2) Specific activity and nuclide content

(3) Technical flexibility of the process taking into consideration variability of waste feed: concentration, moisture, solid content, chemical composition, feed flow rates, and waste generation rates

(4) Maintenance

(5) Previous operating experience

(6) Potential for air-borne contamination.

4.3.3.3 The conditioning process shall ensure that the waste forms have characteristics which meet the transport, storage or disposal criteria. These characteristics may include: chemical durability, thermal stability, radiation stability, aging behaviour, shock resistance, biological resistance, leach resistance, flammability and compressive strength.

4.4 Storage

In designing storage facilities, consideration shall be given to ensuring:

(1) Safe handling of wastes

(2) Maintenance of waste package integrity for a definite period of time with respect to external conditions and possible degradation of waste

(3) Retrievability of wastes

(4) Control of storage area (security, monitoring, fire protection)

(5) Prevention of contamination from gaseous or liquid releases

(6) Provision for decontaminating individual containers and facility surfaces should decontamination be required.

(7) Clear identification.

5. OPERATION OF WASTE MANAGEMENT SYSTEMS

5.1 Objectives

The objective of waste management operation is to operate the waste management facilities according to the design intent. The achievement of this primary objective requires the supervision of all related activities, adequate repair and maintenance procedures, and the provision of operations related information (i.e. process, operating, and maintenance manuals).

5.2 Operational requirements

The Licensee has the overall responsibility for the safe operation of the facility, and shall establish an operating organization of appropriate competence with a clearly defined distribution of duties and responsibilities for the following management functions:

(1) Operation of the facility consistent with the design objectives

(2) Adequate supervision of all waste system activities to ensure that a suitable standard of operation of the system is achieved and maintained

(3) Carrying out maintenance procedures in a manner consistent with radiation protection principles

(4) Adequate operator and maintenance worker training to ensure operational compliance with the design objectives and radiation protection principles

(5) Provision of operating, maintenance and process manuals

5.3 Maintenance

Maintenance procedures shall be developed in as much detail as practicable before operation of the waste management facilities. This will ensure adequate consideration of maintenance requirements prior to operation and permit suitable maintenance training and acquisition of spare parts. Suitable consideration of maintenance requirements will ensure maximum system availability.

5.4 Training

5.4.1 Training programmes shall be developed to ensure a sufficient number of operators and maintenance personnel are available. Training should be given to permit a suitable response to all credible situations.

5.4.2 Training should extend to the personnel generating the waste so that the benefits of lowering waste volumes, activity levels etc. are identified to the appropriate personnel.

5.5 Manuals

The Licencee shall provide manuals describing the waste management system process, operation and maintenance. The manuals should include all process parameters which have to be controlled, waste form properties and container specifications of relevance to storage, transport and disposal.

Where appropriate these manuals should conform with the

corresponding manuals for a nuclear power plant as prescribed in the Agency's Safety Standard No. 50-C-O.

5.6 Supervision

Supervision shall be provided to ensure system related activities are coordinated and levels of performance met. Supervision should be qualified, both radiologically and technically, to supervise all activities related to the operation and maintenance of the radioactive waste management facilities.

6. SURVEILLANCE AND MONITORING OF WASTE MANAGEMENT SYSTEMS

6.1 Objectives

Objectives of the surveillance and monitoring of waste management systems are:

(1) To give information about the sources and characteristics of radioactive wastes, and to provide adequate information to demonstrate compliance with authorizations;

(2) To ensure correct operation of the treatment system (measurements before waste treatment and on treatment system effluents);

(3) To enable control to be exercised on releases of radioactive materials (monitors in the discharge lines with the capability to give alarm and, if required, to terminate automatically the discharge of effluents when radionuclide concentrations exceed a predetermined level).

(4) To ensure that packages of solid wastes comply with transportation requirements as defined by the regulatory authorities for the off-site transport of radioactive materials.

(5) To ensure proper operation of the waste treatment and conditioning systems

Reference may be made also to IAEA Safety Series Report No. 46 for primary objectives of effluent monitoring.

6.2 Requirements

The Licensee shall be responsible for the provision of adequate monitoring and surveillance equipment and personnel to meet the objectives stated in section 6.1.

6.3 Monitoring of gaseous and liquid effluents

6.3.1 All monitoring programmes shall consider:

(1) Main radionuclides to be monitored and measuring sensitivities

(2) Measuring ranges for extreme conditions

(3) Frequency of sampling and analysis

(4) Representativeness of samples taken

(5) Accessibility for sampling, especially in abnormal situations

(6) Avoid confusion among radionuclides detected.

6.3.2 In plant monitoring shall be implemented together with environmental monitoring, intended to measure levels of main radioactive contaminants in selected environmental media.

Information of the objectives and design of environmental monitoring programmes is given in the IAEA Safety Series No. 41.

6.3.3 Additional monitoring should be carried out to monitor non-routine releases following or during unusual occurrences.

6.4 Monitoring of solid wastes

For wastes (shipped off-site) contact dose rate and the loose surface contamination shall be determined to meet transportation regulation. In addition to those required for transport purposes specific radionuclide measurements or

analyses should be required in order to quantify disposal site inventories of radionuclides important for disposal.

6.5 Sampling

Continuous sampling shall be required when there could be wide variations in the concentration of the radionuclides or in the discharge-rate of the effluents, or when the likelihood and potential consequences of unplanned releases are substantial; if the discharge-rate may vary widely, it should also be continuously measured and recorded.

Sampling is described in referred IAEA Safety Series No. 46.

6.6 Recording and reporting monitoring results

6.6.1 The recording and reporting of monitoring data and related information shall be accomplished in a manner that satisfies the objectives described in section 6.1.

6.6.2 Monitoring data should be recorded in the units of measurement that are actually given by the counting and monitoring instruments. Other values calculated or derived from these data should be recorded in addition to, but not in place of, the measured values.

6.6.3 The reports of monitoring results should be expressed in a form which facilitates comparison with the applicable authorized limits or standards. The results of effluent monitoring should be reported periodically. The frequency details of the reporting procedure will be established by the regulatory authority.

6.6.4 Monitoring data for each type of effluent (airborne or liquid) should be obtained and recorded in such a way that the data can be reported in a uniform manner. Shipping and disposal records shall be required on each container transported for disposal.

7. TRANSPORT OF WASTES

7.1 Off-site transport

7.1.1 Off-site transport shall comply with the national regulations for transport of radioactive materials. Such national regulations are often based on the IAEA Regulations for the Safe Transport of Radioactive Materials.

7.1.2 Consideration should further be given to the means and to the routes by which the wastes are transported so as to limit the hazards of transport while keeping costs at the minimum.

7.2 On-site transport

7.2.1 Transport of radioactive waste within the plant or the site boundaries shall comply with the regulations given by national regulatory bodies. The Regulations by IAEA do not apply in this case, but could nevertheless be used.

7.2.2 Minimum requirements on such transports should ensure adequate radiation protection for site personnel and adequate prevention of activity release to the environment due to vehicle or handling accidents.

8. DISPOSAL

8.1 Radioactive waste shall be disposed of in compliance with regulations set by the appropriate regulatory body. A national radioactive waste management policy should be established which states the time schedule of disposal and the responsibilities for its implementation and financing. Adequate interim storage facilities shall be provided until an approved disposal route is available.

8.2 Waste conditioned for disposal shall comply with criteria established by the regulatory authority. Such criteria should be based on a safety assessment of the selected disposal.

Criteria for land disposal are given in IAEA document "Criteria for Underground Disposal of Solid Radioactive Waste" (under preparation).

Disposal in shallow ground or in rock cavities is generally acceptable for solid reactor wastes from nuclear power plant operation since such waste normally contains only moderate amounts of fission products and insignificant amounts of alpha-emitting or long-lived radionuclides. The choice between shallow ground disposal and disposal in rock cavities will normally depend on the availability of suitable sites for either type of repository and on national waste management strategy. On-site availability of a repository should be considered as advantageous since it eliminates the need for off-site transport of the wastes.

Further guidance is given in IAEA Safety Series Nos. 53, 54 and 56 and other documents published under the IAEA Underground Disposal Programme.

8.3 If sea dumping of low-level solid waste is considered to be a justifiable option, it shall be carried out under the provisions of the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Dumping Convention of 1972) after authorization by the competent national authority.* Reference should also be made to the Revised Definition of High-level Radioactive Waste Unsuitable for Dumping in the Ocean and to IAEA document on Control of Radioactive Waste Disposal into the Marine Environment. The IAEA requirements for sea dumping should be considered as minimal requirements by Member States.

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* Guidance for the implementation and surveillance is provided through the OECD's Multilateral Consultation and Surveillance Mechanism for Sea Dumping of Radioactive Wastes (1977).

9. WASTE MANAGEMENT ASPECTS OF DECOMMISSIONING

9.1 All actions undertaken after the termination of the useful life of a nuclear power plant, shall be governed by the general principles of waste management provided in Section 2.

9.2 Decisions by the responsible organization to proceed through the various stages of decommissioning shall be authorized by the competent national authority. Such authorizations should only be given under the condition that adequate facilities are available for transport, storage, and/or disposal of the ensuing waste.

9.3 Large quantities of conventional and radioactive wastes result from the decommissioning of a nuclear power plant. These wastes may be different from those arising during normal plant operation and may need special handling and treatment. They should be characterized according to the level of activity, the physical form and size, and the nature of the materials. A rational set of limits should be developed from which can be deduced what materials can be released for unrestricted use or disposal. Materials which cannot be released shall be disposed of according to established regulations.

10. CONSIDERATIONS FOR WASTES FROM UNPLANNED EVENTS

10.1 An unplanned event is an incident or major maintenance operation which generates unexpected or non-routine wastes. Immediate actions taken to mitigate the consequences of such an incident are not considered to be applicable to this chapter. In respect to the wastes resulting from such an event adequate planning shall be carried out prior to initiating waste management activities.

The occurrence of unplanned events at a nuclear power plant may produce wastes, either gaseous, liquid, or solid, which have volumes, chemical composition and activity contents outside the ranges on which the approval of the waste management procedures have been based.

10.2 The regulatory authority and the implementing organizations should maintain flexibility in considering unique wastes and in the practices for storage and waste disposal. Regulatory authorities should address the waste management criteria for these wastes on an ad-hoc basis.

10.3 The waste management plan should be carefully developed by implementing organizations to address the safe operation and the environmental effects of the proposed waste management activities factoring in considerations of the unique nature of the wastes.

10.3 For wastes generated from unplanned events the disposal considerations will dictate the required treatment and conditioning. Therefore, the available methods of disposal and the acceptability of the generated waste forms for disposal shall be given important consideration in the development of the plan for managing these wastes. The plan should also address the effectiveness of the treatment and conditioning processes considering the waste characteristics.

Population and occupational exposures for the treatment, conditioning, storage and disposal activities shall be maintained as low as reasonably achievable.

11. QUALITY ASSURANCE

11.1 The Licensee shall be responsible for the preparation and operation of a comprehensive quality assurance programme for the waste management system for waste from a nuclear power plant. This programme should be developed and implemented with the help of the IAEA Code of Practice No. 50-C-QA and shall include the design, procurement, manufacture, construction, and operation of system components. Calibration and operation of instrumentation and monitoring systems shall also be included. An operator training programme shall be established.

11.2 The quality assurance aspects for the operation of the conditioning systems shall include a process control programme which will assure that an acceptable waste form and, where applicable, the packaging is consistently produced. This process control programme shall include a system qualification, whereby an envelope of process parameters are established for effective conditioning by testing the actual equipment using simulated, non-radioactive materials and representative or radioactive materials to the extent practicable. The process control programme shall also include measures to verify periodically the acceptability of the process parameters and modify the parameters, if necessary.

11.3 The quality assurance programme shall also provide for the preparation, maintenance, and use of shipping and disposal records and documentation. A manifest system to account for and trace waste package transfers and shipments should be established.

12. WASTE MANAGEMENT CONSIDERATION ASSOCIATED WITH SPENT FUEL

12.1 It should be recognized that wastes will be generated as a result of further management of spent fuel management. Provisions shall, therefore, have to be made for management of such wastes, at the appropriate time, consistent with the objectives presented in this Code.

12.2 Specific practices for spent fuel management will be dependent on technical, economic and political factors. Possible alternative practices include storage until a decision to reprocess or dispose is made, disposal as spent fuel or reprocessing and the associated waste management either in the country of origin or elsewhere. Wastes containing significant amounts of radionuclides, e.g., spent nuclear fuel and high-level or alpha-contaminated wastes from reprocessing of spent fuel will have to be disposed in a manner which assures adequate isolation from the environment.

12.3 In order to assure that technical, economic and political factors are considered in spent fuel management decisions, plans should be developed and evaluated which address national policies, licensing requirements, available resources and spent fuel generation rates. Such plans should be developed and implemented with the help of IAEA Codes of Practice and Safety Guides.

DEFINITIONS

The following definitions are taken from the IAEA TECDOC-264 "Radioactive Waste Management Glossary" and are intended to be used as a standard terminology for IAEA use. The definitions may not necessarily conform to definitions adopted elsewhere for international use.

activation product, neutron: An element made radioactive by bombardment with neutrons.

activity: For an amount of a radioactive nuclide in a particular energy state at a given time, the quotient of dN by dt, where dN is the expectation value of the number of spontaneous nuclear transitions from that energy state in the time interval dt. The special name for the SI unit of activity is becquerel (Bq); the curie (Ci) may be used temporarily. (See ICRU Report 33.)

AGR: Advanced gas-cooled reactor.

ALARA: "As low as reasonably achievable, economic and social factors being taken into account." A basic principle of radiation protection taken from the Recommendations of the ICRP, ICRP Publication No. 26 (p.3).

alpha-bearing waste: Waste containing one or more alpha-emitting radionuclides, usually actinides, in quantities above acceptable limits. The limits are established by the national regulatory body.

arisings, waste: See waste arisings.

BWR: Boiling water reactor.

code: As used by the IAEA, a body of advisory or regulatory statements which establish for particular activities the minimum requirements which, in the light of experience and/or the current state of technology and knowledge, should be fulfilled to ensure adequate radiological safety.

conditioning of waste: Those operations that transform waste into a form suitable for transport and/or storage and/or disposal. The operations may include converting the waste to another form, enclosing the waste in containers, and providing additional packaging.

containment: The retention of radioactive material in such a way that it is effectively prevented from becoming dispersed into the environment or only released at an acceptable rate.

contamination, radioactive: A radioactive substance in a material or place where it is undesirable.

criteria: Principles or standards on which a decision or judgement can be based. They may be qualitative or quantitative. Acceptability criteria are set by a regulatory authority. (Some Member States use terms such as 'protection goals' instead of 'acceptability criteria'.)

decay, radioactive: A spontaneous nuclear transformation in which particles or gamma radiation are emitted, or X radiation is emitted following orbital electron capture, or the nucleus undergoes spontaneo s fission.

decommissioning: The work required for the planned permanent retirement of a nuclear facility from active service. Different regulations will apply thereafter. (In some Member States a facility is not regarded as decommissioned until it is suitable for unrestricted use.) (See stage of decommissioning.)

decontamination: Removal or reduction of radioactive contamination.

disposal: The emplacement of waste materials in a repository, or at a given location, without the intention of retrieval. Disposal also covers direct discharge of both gaseous and liquid effluents into the environment. (See storage.)

dose: A general term denoting the quantity of radiation or the radiation energy absorbed by a medium. Dose should be qualified as absorbed dose, dose equivalent, effective dose equivalent, effective dose equivalent commitment, committed dose, or collective dose. Dose alone may be used when it does not matter if reference is made to absorbed dose or dose equivalent.

engineered storage: The storage of radioactive wastes, usually in suitably sealed containers, in any of a variety of structures especially designed to protect them and to help keep them from leakage to the biosphere by accident or sabotage. They may also provide for extracting heat of radioactive decay from the waste.

environment:

(i) The surroundings of an installation. (The immediate surroundings are termed the environs.)

(ii) The sum total of all the conditions and influences that surround an organism, human or otherwise, that affect its life, survival and development.

exposure:

(i) A general term relating to the incidence of ionizing radiation on living or inanimate material, by accident or intent.

(ii) The quotient of dQ by dm where the value of dQ is the absolute value of the total charge of the ions of one sign produced in air when all the electrons (negatrons and positrons) liberated by photons in air of mass dm are completely stopped in air. The special unit of exposure, roentgen (R), may be used temporarily. (See ICRU Report 33.)

fissile material: A (radioactive) material containing one or more fissile nuclides.

fission product: A nuclide produced either by fission or by the subsequent radioactive decay of a radioactive nuclide thus formed.

fuel, nuclear reactor: Fissile and fertile material used as the source of energy when placed in a critical arrangement in a nuclear reactor.

fuel cycle: All of the steps involved in supplying and using fuel materials for nuclear power reactors, including related waste management operations.

geological disposal: See underground disposal.

guide: As used by the IAEA, a document providing general guidance on a procedure or procedures that might be followed in implementing a code.

high-level waste:

(i) The highly radioactive liquid, containing mainly fission products, as well as some actinides, which is separated during chemical reprocessing of irradiated fuel (aqueous waste from the first solvent extraction cycle and those waste streams combined with it).

(ii) Spent reactor fuel, if it is declared a waste.

(iii) Any other waste with a radioactivity level comparable to (i) or (ii).

(Note that these definitions are not related to "high-level radioactive waste unsuitable for dumping in the ocean", as used in the London Dumping Convention. See IAEA/INFCIRC/205/Add.1/Rev.1.)

HTGR: High temperature gas-cooled reactor.

ICRP limit: A primary dose equivalent limit recommended by the ICRP. Dosimetric models may be used to derive the annual limit on intake (ALI) and derived air concentration (DAC).

immobilization of waste: Conversion of a waste to a solid form that reduces the potential for migration or dispersion of radionuclides by natural processes during storage, transport and disposal.

implementing organization: The organization (and its contractors) that performs activities in order to select and investigate the suitability of a site for a nuclear facility, and that undertakes to design, construct, commission, operate and shut down such a facility.

incineration: The process of burning a combustible material to reduce its volume and yield an ash residue.

inspection: Quality control actions which, by means of examination, observation or measurement, determine whether materials, parts, components, systems, structures as well as processes and procedures, conform to predetermined quality requirements.

interim storage (storage): A storage operation for which (a) monitoring and human control are provided and (b) subsequent action involving treatment, transportation, and final disposition is expected.

intermediate-level waste (or medium-level waste): Waste of a lower activity level and heat output than high-level waste, but which still requires shielding during handling and transportation. The term is used generally to refer to all wastes not defined as either high-level or low-level. (See alpha-bearing waste and long-lived waste for other possible limitations.)

leachability: The susceptibility of a solid material to having its soluble, sorbed and/or suspendable constituents removed by the dissolving or erosive action of water or other fluids.

leaching:

(i) Extraction of a soluble substance from a solid by a solvent with which the solid is in contact.

(ii) The term is often used in waste management to describe the gradual dissolution/erosion of emplaced solid waste or chemicals therefrom, or the removal of sorbed material from the surface of a solid or porous bed.

license: Formal document, issued by the regulatory body for major stages in the development of a nuclear facility, defined by regulations

permitting the holder (the implementing organization) to perform specified activities.

long-lived nuclide: For waste management purposes, a radioactive isotope with a half-life greater than about 30 years.

long-term: In waste management, refers to periods of time which exceed the time during which administrative controls can be expected to last.

low-level waste: Waste which, because of its low radionuclide content, does not require shielding during normal handling and transportation. (See alpha-bearing waste and long-lived waste for other possible limitations.)

LWR (light water reactor): Nuclear reactor that employs H_2O as a coolant and moderator.

nuclear fuel: Fissionable and/or fertile material for use as fuel in a nuclear reactor.

nuclear installation (or nuclear facility): Any installation in which radioactive or fissile materials are produced, processed or handled on such a scale that considerations of nuclear safety are necessary.

nuclear power plant: A nuclear reactor or reactors together with all structures, systems and components necessary for safety and for the production of power, i.e. heat or electricity.

nuclide: A species of atom characterized by its mass number, atomic number, and nuclear energy state. (See radionuclide.)

operating organization: The organization authorized by the regulatory authority to operate the nuclear facility.

operation: All activities performed to achieve, in a safe manner, the purpose for which the facility was constructed, including maintenance, in-service inspection and other associated activities.

operating records: A set of documents, such as instrument charts, certificates, log books, computer print-outs and magnetic tapes, kept at each nuclear facility and organized in such a way that they provide a complete and objective history of the operation of the facility.

operations, waste management: Broad classification of waste management activities in terms of their basic function (e.g. waste storage, treatment, transportation or disposal).

operator: Any person, government or other entity that conducts or carries on operations at a nuclear facility.

optimization: As used in radiation protection practice, the process of reducing the expected detriment deriving from radiation exposure of a population, through the use of protective measures, to as low as reasonably achievable, economic and social factors being taken into account. (See ALARA, detriment.)

owner: Any person, government or other entity that holds title to or owns the land upon which a mine, plant or other facility is located.

package, waste: See waste package.

PWR: Pressurized water reactor.

qualified person: A person who, having complied with specific requirements and met certain conditions, has been officially designated to discharge specified duties and responsibilities.

quality assurance: Planned and systematic actions necessary to provide adequate confidence that an item, facility or person will perform satisfactorily in service.

quality control: Actions which provide a means to control and measure the characteristics of an item, process, facility or person in accordance with quality assurance requirements.

radiation protection or radiological protection:

(i) All measures associated with the limitation of the harmful effects of ionizing radiation on people, such as limitation of external exposure to such radiation, limitation of bodily incorporation of radionuclides as well as the prophylactic limitation of bodily injury resulting from either of these.

(ii) All measures designed to limit radiation-induced chemical and physical damage in materials.

radioactive material: A material of which one or more constituents exhibit radioactivity.

Note: For special purposes such as regulation, this term may be restricted to radioactive material with a radioactivity level or specific activity greater than a specified value.

radioactive waste: Any material that contains or is contaminated with radionuclides at concentrations or radioactivity levels greater than the 'exempt quantities' established by the competent authorities and for which no use is foreseen.

radioactivity: The property of certain nuclides of spontaneously emitting particles or gamma radiation, or of emitting x-radiation following orbital electron capture, or of undergoing spontaneous fission.

radionuclide: A radioactive nuclide.

radwaste: See radioactive waste.

regulatory authority or regulatory body: An authority or system of authorities designated by the Government of a Member State as having the legal authority for conducting the licensing process, for issuing of licenses and thereby for regulating the siting, design, construction, commissioning, operation, shut-down, decommissioning and subsequent control of nuclear facilities (e.g. waste repositories) or specific aspects thereof. This authority could be a body (existing or to be established) in the field of nuclear-related health and safety or mining safety or environmental protection, vested with such legal authority, or it could be the Government or a department of the Government, or it could be an international agency.

regulatory inspection: An examination, observation, measurement or test undertaken by or for the regulatory authority during any stage of the licensing process to ensure conformance of materials, components, systems and structures, as well as operational activities, processes, procedures and personnel competence, with predetermined requirements.

repository: An underground facility in which waste may be emplaced for disposal.

Note: Some Member States use the term 'vault' as a synonym.

repository system: A repository and all its supporting facilities.

reprocessing, fuel: The processing of nuclear fuel, after its use in a reactor, to remove fission products and recover fissile and fertile material.

responsible organization: The organization having overall responsibility for a nuclear installation or facility.

rock: To the geologist any mass of mineral matter, whether consolidated or not, which forms part of the Earth's crust is a rock. Rocks may consist of only one mineral species, in which case they are called monomineralic, but they more usually consist of an aggregate of mineral species.

safety: Protection of persons and property from undue hazard (risk).

safety analysis: The analysis and calculation of the hazards (risks) associated with the implementation of a proposed activity.

safety assessment: A comparison of the results of safety analyses with acceptability criteria, its evaluation, and the resultant judgements made on the acceptability of the system assessed.

safety report: A document, required of the implementing organization by the regulatory authority, containing information concerning a nuclear installation (e.g. a waste repository), the site characteristics, design, operational procedures, etc., together with a safety analysis and details of provisions aimed at reducing the risk to the site personnel and to the public. (See ALARA.).

shallow-ground disposal (e.g. shallow-ground burial): Disposal of radioactive waste, with or without engineered barriers, above or below the ground surface, where the final protective covering is of the order of a few metres thick. Some Member States consider 'shallow-ground disposal' to be a mode of storage rather than a mode of disposal.

short-lived nuclide: For waste management purposes, a radioactive isotope with a half-life shorter than about 30 years, e.g. ^{137}Cs, ^{90}Sr, ^{85}Kr, ^{3}H.

site: The area containing a nuclear installation, (e.g. a waste repository) that is defined by a boundary and which is under effective control of the implementing organization.

siting: The process of selecting a suitable site for an installation, including appropriate assessment and definition of the related design bases.

solidification: Conversion of liquid or liquid-like materials into a solid.

spent fuel: Nuclear reactor fuel elements that have been irradiated in a reactor and have been utilized to an extent such that their further use is no longer efficient.

stage of decommissioning: The term 'stage', in IAEA usage, implies a state or condition of a facility after decommissioning activities:
Stage 1 - storage with surveillance;
Stage 2 - restricted site release;
Stage 3 - unrestricted site release.

These stages are discussed in IAEA Safety Series No. 52, pp.3-5. The term does not necessarily imply a step-wise procedure through various 'stages', as indicated by normal usage of the word. Thus, decommissioning to 'stage' 2 does not necessarily have to be preceded by going through 'stage' 1, and 'stage' 3 does not have to be preceded by 'stages' 1 and 2. Many Member States prefer and/or use other terms such as 'alternative', 'level', 'option', 'mode', etc. in place of 'stage'. (See decommissioning.)

storage (or interim storage): The emplacement of waste in a facility with the intent that it will be retrieved at a later time.

surveillance:
(i) Includes all planned activities performed to ensure that the conditions at a nuclear installation remain within the prescribed limits; it should detect in a timely manner any unsafe condition and the degradation of structures, systems and components which could at a later time result in an unsafe condition. These activities can be classified as:

(a) monitoring of individual parameters and system status;
(b) checks and calibrations of instrumentation;
(c) testing and inspection of structures, systems and components;
(d) evaluation of the results of items (a) and (c).

(ii) As used with IAEA Safeguards, the collection of information through devices and/or inspector observation in order to detect undeclared movements of nuclear material, tampering with containment, falsification of information related to locations and quantities of nuclear material, and tampering with IAEA safeguards devices.

testing: Determination or verification of the capability of a component or assembly of components to meet specified requirements by subjecting the component or assembly to a set of physical, chemical, environmental or operational conditions.

transuranic (TRU) waste: Waste containing quantities of nuclides having atomic numbers above 92 above agreed limits. The limits are established by national regulatory bodies. (See alpha-bearing waste.)

treatment of waste: Operations intended to benefit safety or economy by changing the characteristics of the waste. Three basic treatment concepts are:

(a) volume reduction;
(b) removal of radionuclides from the waste;
(c) change of composition. (See conditioning)

underground disposal: Disposal of waste at an appropriate depth below the ground surface.

validation: A conceptual model and the computer code derived from it are 'validated' when it is confirmed that the conceptual model and the derived computer code provide a good representation of the actual

processes occurring in the real system. Validation is thus carried out by comparison of calculations with field observations and experimental measurements.

verification: A computer code is 'verified' when it is confirmed that the conceptual model of the real system is adequately represented by the mathematical solution. Verification can thus be carried out, for example, by intercomparison of codes and by comparison of numerical codes with analytical solutions.

waste arisings: Radioactive wastes generated by any stage in the nuclear fuel cycle.

waste disposal: See disposal.

waste form: The physical and chemical form of the waste (e.g. liquid, in concrete, in glass, etc.) without its packaging.

waste management: All activities, administrative and operational, that are involved in the handling, treatment, conditioning, transportation, storage and disposal of waste.

waste package: The waste form and any container(s) as prepared for handling, transportation, storage and/or disposal. A cask or overpack may be a permanent part of the waste package or it may be re-usable for any waste management step. The waste package may vary for the different steps in waste management.

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