CODE NO. AERB/NRF/SC/RW

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GOVERNMENT OF INDIA

AERB SAFETY CODE

MANAGEMENT OF RADIOACTIVE WASTE

ATOMIC ENERGY REGULATORY BOARD

AERB CODE NO. AERB/NRF/SC/RW

MANAGEMENT OF RADIOACTIVE WASTE

Approved by the Board on June 22, 2007

Atomic Energy Regulatory Board
Mumbai-400 094
India
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Price:

Orders for this Code should be addressed to:

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FOREWORD

Activities concerning establishment and utilisation of nuclear facilities and use of radioactive sources are to be carried out in India in accordance with the relevant provisions of the Atomic Energy Act, 1962. In pursuance of the objective to ensure safety of members of the public and occupational workers, as well as protection of environment, the Atomic Energy Regulatory Board (AERB) has been entrusted with the responsibility of laying down safety standards and framing rules and regulations for such activities. The Board has, therefore, undertaken a programme of developing safety standards, safety codes and related safety guides and manuals for the purpose. While some of the documents cover aspects such as siting, design, construction, operation, quality assurance and decommissioning, other documents cover regulation aspects of facilities.

Safety codes and safety standards are formulated on the basis of nationally and internationally accepted safety criteria for design, construction and operation of specific equipment, structures, systems, components of nuclear and radiation facilities. Safety codes establish the safety objectives and set minimum requirements that shall be fulfilled to provide adequate assurance for safety. Safety guides elaborate various requirements and furnish approaches for their implementation. Safety manuals deal with specific topics and contain detailed scientific and technical information on the subject. These documents are prepared by experts in the relevant fields and are extensively reviewed by Advisory Committees of the Board before they are published. The documents are revised when necessary, in the light of experience and feedback from users as well as new developments in the field.

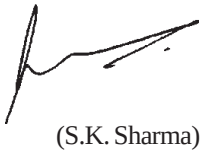
This safety code specifies requirements to be met in the management of radioactive waste at nuclear and radiation facilities. In drafting this code, information contained in relevant documents published by the International Atomic Energy Agency (IAEA) under the Radioactive Waste Safety Standards (RADWASS) programme and those under Safety Series and other international publications have been extensively used.

Consistent with the accepted practice, ‘shall’ and ‘should’ are used in the code to distinguish between a firm requirement and a desirable option, respectively. Appendices are an integral part of the document, whereas annexures and references/ bibliography are included to provide further information on the subject that might be helpful to the user.

For aspects not covered in this code, applicable national and international standards, codes and guides acceptable to AERB should be followed. Non-radiological aspects of environmental protection and industrial safety are not explicitly considered. Industrial safety is to be ensured through compliance with the applicable provisions of the Factories Act, 1948 and the Atomic Energy (Factories) Rules, 1996 and the Environmental Protection Act, 1984.

This code has been prepared by specialists in the field drawn from the Atomic Energy Regulatory Board, Bhabha Atomic Research Centre, Indira Gandhi Centre for Atomic Research, Nuclear Power Corporation of India Ltd. and other consultants. It has been reviewed by the relevant AERB Advisory Committee on Codes and Guides and the Advisory Committee on Nuclear Safety.

AERB wishes to thank all individuals and organisations who have prepared and reviewed the draft and helped in its finalisation. The list of persons, who have participated in this task, along with their affiliations, is included for information.



(S.K. Sharma)
Chairman, AERB

DEFINITIONS

Acceptable Limits

Limits acceptable to the regulatory body for accident condition or potential exposure.

Accident

An unplanned event resulting in (or having the potential to result in) personal injury or damage to equipment which may or may not cause release of unacceptable quantities of radioactive material or toxic/hazardous chemicals.

Alpha-bearing Waste

Waste containing one or more alpha-emitting radionuclides in quantities and/or concentrations above clearance levels.

Approval

A type of regulatory consent issued by the regulatory body to a proposal.

Assessment

Systematic evaluation of the arrangements, processes, activities and related results for their adequacy and effectiveness in comparison with set criteria.

Atomic Energy Regulatory Board (AERB)

A national authority designated by the Government of India having the legal authority for issuing regulatory consent for various activities related to the nuclear and radiation facility and to perform safety and regulatory functions, including their enforcement for the protection of the site personnel, the public and the environment from undue radiation hazards.

Authorisation

A type of regulatory consent issued by the regulatory body for all sources, practices and uses involving radioactive materials and radiation generating equipment (See also 'Consent').

Authorised Limit

Limits established or accepted by the regulatory body.

Clearance Levels

A set values established by the regulatory body and expressed in terms of activity concentrations and/or total activity, at or below which sources of radiation may be released from regulatory control.

Conditioning of Waste

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

Confinement

Barrier, which surrounds the main parts of a nuclear facility, carrying radioactive materials and designed to prevent or to mitigate uncontrolled release of radioactivity into the environment during commissioning, operational states, during design basis accidents or in decommissioning phase.

Consent

A written permission, issued to the "consentee" by the regulatory body to perform specified activities related to nuclear and radiation facilities. The types of consents are 'licence', 'authorisation', 'registration' and 'approval', and will apply according to the category of the facility, the particular activity and radiation source involved.

Decommissioning

The process by which a nuclear or radiation facility is finally taken out of operation in a manner that provides adequate protection to the health and safety of the workers, the public and of the environment.

Design

The process and the results of developing the concept, detailed plans, supporting calculations and specifications for a nuclear or radiation facility.

Discharge (Radioactive)

Planned and controlled release of (gaseous or liquid) radioactive material into the environment.

Disposal (Radioactive Waste)

The emplacement of waste in a repository without the intention of retrieval or the approved direct discharge of waste into the environment with subsequent dispersion.

Documentation

Recorded or pictorial information describing, defining, specifying, reporting or certifying activities, requirements, procedures or results.

Effluent

Any waste discharged into the environment from a facility, either in the form of liquid or gas.

Emergency

A situation which endangers or is likely to endanger safety of the site personnel, the nuclear/radiation facility or the public and the environment.

Emergency Exercise

A test of an emergency plan with particular emphasis on coordination of the many interphasing components of the emergency response, procedures and emergency personnel/agencies. An exercise starts with a simulated/postulated event or series of events in the plant in which an unplanned release of radioactive material is postulated.

Emergency Plan

A set of administrative procedures to be implemented in the event of an accident.

Exempt Waste

Waste, which is cleared from regulatory control in accordance with clearance levels. The designation should be in terms of activity concentration and/or total activity and may include a specification of the type, chemical/physical form, mass or volume of waste.

High Level Waste (HLW)

A type of waste, which contains any of the following:

- The radioactive liquid containing most of the fission products and actinides present in spent fuel, which forms the residue from the first solvent extraction cycle in reprocessing; and some of the associated waste streams;
- Solidified high level waste from above and spent reactor fuel (if it is declared a waste);
- Any other waste with similar radiological characteristics.

Incident

Events that are distinguished from accidents in terms of being less severe. The incident although not directly or immediately affecting plant safety, has the potential of leading to accident conditions with further failure of safety system(s).

Institutional Control (Radioactive Waste)

The process of controlling the radioactive waste site by an authority or institution designated under the laws of the country. This control may be active (monitoring, surveillance, remedial work) or passive (land use control) and may be a factor in the design of a nuclear/ radiation facility.

Licence

A type of regulatory consent, granted by the regulatory body for all sources, practices

and uses for nuclear facilities involving the nuclear fuel cycle and also certain categories of radiation facilities. It also means authority given by the regulatory body to a person to operate the above said facilities.

Long-lived Wastes

Radioactive wastes containing long-lived radionuclides having sufficient radiotoxicity and/or concentrations requiring long time isolation from the biosphere. The term long-lived radionuclides refers to half lives usually greater than 30 years.

Low and Intermediate Level Waste (LILW)

Radioactive wastes in which the concentration or quantity of radionuclides is above clearance levels established by the regulatory body, but with a radionuclide content and thermal power below those of high level waste. Low and intermediate level waste is often separated into short lived and long lived wastes.

Near Surface Disposal

Disposal of waste with/without engineered barriers, or below the ground surface with adequate final protection covering to bring the surface dose rate within prescribed limits.

Nuclear Fuel Cycle

All operations associated with the production of nuclear energy, including mining, milling, processing and enrichment of uranium or processing of thorium, manufacture of nuclear fuel, operation of nuclear reactors, reprocessing of irradiated nuclear fuel, decommissioning, and any activity for radioactive waste management and research or development activity related to any of the foregoing.

Pre-treatment (Radioactive Waste)

Any operation/conditioning of waste prior to final treatment before disposal.

Radiation Facility

Any installation/equipment or a practice involving use of the radiation-generating units or use of radioisotopes in the field of research, industry, medicine and agriculture.

Radioactive Waste

Material, whatever its physical form, left over from practices or interventions for which no further use is foreseen (a) that contains or is contaminated with radioactive substances and has an activity or activity concentration higher than the level for clearance from regulatory requirements, and (b) exposure to which is not excluded from regulatory control.

Radioactive Waste Management Facility

Facility specifically designed to handle, treat, condition, temporarily store or permanently dispose of radioactive wastes.

Regulatory Body

See 'Atomic Energy Regulatory Board'.

Safety Analysis

Evaluation of the potential hazards (risks) associated with the implementation of a proposed activity.

Safety Assessment

A review of the aspects of design and operation of a source which are relevant to the protection of persons or the safety of the source, including the analysis of the provisions for safety and protection established in the design and operation of the source and the analysis of risks associated both with normal conditions and accident situations.

Segregation (Radioactive Waste)

An activity where waste or materials (radioactive and exempt) are separated or are kept separate according to radiological, chemical and/or physical properties to facilitate waste handling and/or processing. It may be possible to segregate radioactive material from exempt material and thus reduce the waste volume.

Spent Fuel

Irradiated fuel not intended for further use in reactors in its present form.

Storage (Radioactive Waste)

The placement of radioactive waste in an appropriate facility with the intention of retrieving it at some future time. Hence, waste storage is by definition an interim measure and the term interim storage should not be used.

Surveillance

All planned activities, viz. monitoring, verifying, checking including in-service inspection, functional testing, calibration and performance testing carried out to ensure compliance with specifications established in a facility.

Waste Form

The waste in its physical and chemical form after treatment and/or conditioning prior to packaging.

Waste Immobilisation

The conversion of radioactive waste into a solid form (by solidification, or by embedding or encapsulating in a matrix material) to reduce the potential for migration or dispersion of radionuclides during transport, storage and disposal.

Waste Management

All administrative and operational activities involved in the handling, pre-treatment, treatment, conditioning, transportation, storage and disposal of radioactive waste.

Waste Treatment

Operations intended to benefit safety and/or economy by changing the characteristics of the wastes by employing methods such as:

a) volume reduction;

b) removal of radionuclides;

c) change of composition.

After treatment, the waste may or may not be immobilised to achieve an appropriate waste form.

CONTENTS

1. INTRODUCTION

1.1 General

1.1.1 Radioactive waste is generated during operation, maintenance and decommissioning of nuclear and radiation facilities. The waste generated needs to be managed in a safe manner to ensure protection of human health and the environment from the undue effects of ionising radiation now and in the future without imposing undue burden on future generations.

1.2 Objective

1.2.1 Objective of this safety code is to establish the requirements, which shall be fulfilled for the safe management of solid, liquid and gaseous radioactive waste from generation through disposal [1,2].

1.3 Scope

1.3.1 This safety code specifies basic requirements for the safe management of radioactive waste from nuclear and radiation facilities, such as:

(a) mining and milling and processing of uranium and thorium ores;
(b) fuel fabrication;
(c) nuclear power plants;
(d) research/experimental reactors;
(e) fuel reprocessing;
(f) medical, industrial, agriculture and research facilities using radionuclides; and
(g) other facilities handling radioactive materials.

1.3.2 This safety code deals with the requirements for radiation protection aspects in design, construction and operation of waste management facilities and the responsibilities of different agencies involved [3,4].

1.3.3 This safety code is also applicable to the management of radioactive waste containing, chemically and biologically hazardous substances, even though other specific requirements may additionally be applicable as per relevant standards.

1.3.4 For management of radioactive waste arising from processing of naturally occurring radioactive materials (NORMs) other than uranium mining and milling and processing of thorium, the requirements in this code may not be applicable. In such cases, the extent of the applicability of this code needs to be obtained from the regulatory body on a case-by-case basis.

1.3.5 Specific requirements pertaining to management of radioactive waste from application of sealed/unsealed sources, mining and milling of uranium/thorium

ores and site remediation are covered in Appendices A, B and C respectively. Appendix D provides requirements of transportation/ transfer for radioactive solid and liquid waste.

1.3.6 The principles, philosophy and basic steps of management of radioactive waste are provided in Annexures I and II.

1.3.7 Deep geological disposal methodology of high level radioactive solid waste requiring long time isolation of thousands of years from biosphere is presently under development. Hence this safety code does not cover requirements for deep geological disposal.

2. RADIATION PROTECTION AND ENVIRONMENTAL SAFETY

2.1 General

Radioactive waste is managed in a manner that ensures compliance with the fundamental principles of radiation protection and environmental safety. Monitoring and surveillance programme helps to ensure radiation protection of the occupational workers, public and the environment. Emergency preparedness plan needs to be put in place for minimising the radiological and environmental impact.

2.2 Protection of Human Health and the Environment

2.2.1 Radioactive waste shall be managed within the dose constraints and other safety requirements prescribed by the regulatory body.

2.2.2 Radiation exposure to workers and the public from radioactive waste shall be kept as low as reasonably achievable, social and economic factors being taken into account. A well-defined radiation protection programme shall be established for radioactive waste management. Approved procedures and control measures shall be used for radiation protection.

2.2.3 Radiation exposures to workers and the members of public shall not exceed the limits prescribed by the regulatory body [4].

2.3 Effluent Release Criteria, Control and Monitoring

2.3.1 Radioactive waste shall be characterised, monitored, segregated, treated and conditioned, as necessary, prior to disposal.

2.3.2 Radioactive discharges to the environment (aquatic, atmospheric and terrestrial route) shall not exceed the limits prescribed by the regulatory body [5].

2.3.3 At a given site, facility specific disposal schemes for radioactive solid, liquid and gaseous wastes to the environment shall be established and got approved by the regulatory body prior to the commencement of operation.

2.3.4 The facility shall assess the adequacy of controls on release of activity into the environment and demonstrate compliance with the regulatory requirements. The facility shall obtain approval from the regulatory body, if the discharges exceed the authorised limits.

2.3.5 For all non-radiological releases/discharges, the relevant clearances shall be obtained from respective statutory agencies and stipulations therein shall be complied with.

2.4 Environmental Monitoring and Surveillance

2.4.1 The facility shall implement approved environmental monitoring and surveillance programme for the identified exposure pathways to meet the requirements set by the regulatory body. The programme shall include pre-operational, operational, closure and post-closure monitoring and surveillance.

2.4.2 The facility shall implement approved quality assurance programme on sampling, monitoring and analysis to ensure a reliable data.

2.5 Safety Assessment

2.5.1 A safety assessment report shall be prepared for waste management facilities including waste disposal facilities/ repositories to demonstrate compliance with the regulatory requirements.

2.5.2 Assessments shall be made to identify various possible sequences of internal or external events that may lead to incidents or accidents and to evaluate their impact on workers, the public and the environment.

2.5.3 Assessments shall be made to identify, describe and analyse the potential non-radiological impact of releases from radioactive waste management facilities on human beings, the environment (soil, water, air and non-human biota) and natural resources.

2.5.4 The safety assessments of the long-term performance of a waste disposal facility/ repository shall take account of the radionuclide content, physico-chemical characteristics of the waste/waste form and the effectiveness of engineered/natural barriers.

3. RESPONSIBILITIES ASSOCIATED WITH RADIOACTIVE WASTE MANAGEMENT

3.1 General

3.1.1 Safe management of radioactive waste requires clear allocation of responsibilities of the agencies involved. It may involve transfer of the responsibility of the management of radioactive waste from one facility to another or to a different agency other than the one responsible for the operation of the facility. The continuity of responsibility is therefore, required to be ensured through regulatory control by a licence or a sequence of licences according to the procedures laid down by the regulatory body.

3.2 Responsibilities of the Waste Generator/ Manager

3.2.1 Radioactive waste shall be managed within an appropriate regulatory framework including clear allocation of responsibilities and provision for independent regulatory review.

3.2.2 Radioactive waste generator/manager shall be responsible for all aspects of safe management of radioactive waste.

3.2.3 Radioactive waste management may span time scales involving a number of human generations. Waste generator/manager shall clearly identify and ensure continuity of responsibilities and funding requirements whether these activities are carried out by one agency or several agencies in sequence and shall also cover research and development activities to support operational and regulatory requirements.

3.2.4 Waste generator/manager or both shall be responsible for identifying, on an appropriate time-scale, a destination for the waste in accordance with the regulatory requirements, and for seeking any necessary authorisation. The waste generator/manager shall dispose the radioactive waste in an approved manner or transfer it in an authorised manner to another waste manager for processing, storage or disposal.

3.2.5 Waste generator/manager shall keep the generation of radioactive waste to the minimum practicable by suitable design, operation, post operation and decommissioning of the facility.

3.2.6 Waste generator/manager shall:

a) ensure provision for suitable and sufficient storage capacity on an appropriate time-scale, until relevant disposal routes are available;

b) perform safety and environmental impact assessments of waste management facilities and activities;

c) ensure adequate radiation protection of the workers, the general public and the environment;

d) ensure suitable staff, equipment, facilities, training and operating procedures are available;

e) establish and implement a quality assurance programme (QAP) at all stages;

f) establish and keep records of the generation, processing, storage and transfer/disposal of radioactive waste;

g) provide surveillance and control as required by the regulatory body;

h) use operational experience to improve waste management safety;

i) to carry out/support research and development activities in a time bound manner ensuring adequate funding;

j) address issues related to decommissioning of nuclear and radiation facilities and management of resulting radioactive waste;

k) assume complete responsibility even if the work is delegated to a different agency;

l) establish emergency preparedness commensurate with the type of the facility and associated hazards;

m) ensure effective organisational structure;

n) meet requirements of the regulatory body with respect to normal/off normal discharges and corrective action, if any;

o) obtain consent of the regulatory body for any modification in the design and operation procedures of existing facility;

p) facilitate regulatory inspection and compliance with the recommendations of the regulatory body; and

q) adhere to stipulations by the regulatory body and other statutory bodies.

3.3 Waste Management Interdependency

3.3.1 Interdependency among basic steps in waste management (like minimisation of waste generation at source, segregation, pre-treatment, treatment, conditioning, storage and disposal) shall be taken into account. Decisions on radioactive waste management made at one step should not foreclose other options for, or otherwise affect, a subsequent step.

3.3.2 Waste management safety, operational ease and economy depends on well defined and favourable waste characteristics and quantities. Efforts shall be

made to obtain favourable waste characteristics without compromising the design and operational intent of the waste generating facility.

3.3.3 The waste generator/manager shall examine different processing options, identifying the appropriate one and avoiding conflicting requirements that may compromise safety. An integrated approach should be followed to optimise various steps in the management of radioactive waste.

3.4 Licensing /Authorisation Process

3.4.1 The licensing/authorisation process shall apply to siting, design, construction, commissioning and operation as well as the decommissioning of facilities or closure of a repository [6]. A license or authorisation shall be obtained from the regulatory body for safe management including disposal or transfer of radioactive waste.

3.4.2 Supporting documents along with the application for a license/ authorisation for radioactive waste management shall provide an assurance that:

- the required level of safety including radiation protection of workers and the public, and protection of the environment is provided;
- the generation of radioactive waste in the facility is kept to the minimum practicable, taking into account interdependency among all steps in radioactive waste generation and management;
- any treatment and conditioning of radioactive waste is compatible with the anticipated mode and duration of the storage and the retrievability of the radioactive waste from storage, when needed; and
- account of anticipated waste arising including decommissioning and disposal options through air, water and terrestrial routes in the safety assessment.

4. PREDISPOSAL MANAGEMENT OF RADIOACTIVE WASTE

4.1 General

Predisposal management of radioactive waste comprises steps such as collection, characterisation, segregation, pre-treatment, treatment, conditioning, storage and transport carried out prior to disposal. The design intent of pre-disposal waste management system is to carry out the above operations in a safe manner. Requirements pertaining to design, construction, commissioning and operation of waste management facilities including decommissioning aspects need to be addressed adequately.

4.2 Siting, Design and Construction

4.2.1 Site selection of predisposal waste management facilities shall be governed by AERB siting code [7] and may be limited to site characterisation if co-located with nuclear facilities.

4.2.2 Predisposal waste management facilities shall be designed and constructed for safe and easy operation. Following factors shall be considered in the design and construction of such facilities:

(a) site characteristics and socio economic factors;

(b) radiation protection of occupational workers, public and the environment;

(c) segregation and collection of waste at source into appropriate categories based on its origin and radiological/radiochemical characteristics;

(d) discharge limits;

(e) decay of waste containing short-lived radionuclides;

(f) sampling, analysis and monitoring of waste;

(g) selection and use of reliable waste treatment system;

(h) minimisation of primary and secondary waste;

(i) volume reduction of solid waste by appropriate methods

(j) provision of adequate storage and treatment capacity for normal operation, shutdown and maintenance with adequate redundancy;

(k) provision of additional storage and treatment capacity for postulated events and off normal occurrences;

(l) provision of augmentation, decontamination and decommissioning as applicable;

(m) conditioning of the waste into waste forms and waste packages to comply with waste acceptance criteria for safe transport, storage and/or disposal;

(n) compatibility of material selected;

(o) monitoring and surveillance of facility/site; and

(p) industrial and fire safety.

4.2.3 Predisposal radioactive waste management facilities shall be constructed as per the approved design and specified code and shall also meet the applicable seismic and other requirements.

4.3 Commissioning and Operation

The waste generator/manager shall have the overall responsibility for commissioning and safe operation of the waste management facility. The facility shall be commissioned as per approved procedure. Operation of the facility shall be consistent with the design intent and the consent granted by the regulatory body. The waste generator/manager shall ensure an operating organisation with clearly defined duties and responsibilities. Operation of the facility shall be carried out with the help of adequate number of trained manpower, as per approved operating/maintenance procedures and technical specifications.

4.4 Waste Minimisation, Classification and Categorisation

Operating practices of the facility shall ensure minimum generation of radioactive waste. The waste shall be segregated, classified and categorised to facilitate selection of appropriate processes. A well-defined waste categorisation system shall be adopted for effective communication among various agencies for safe management of radioactive waste.

4.5 Pre-treatment

The objective of pre-treatment is to make the waste amenable to treatment, conditioning, transportation, storage and disposal. Pre-treatment shall be based on the requirements of such subsequent waste treatment/conditioning steps.

4.6 Treatment

The waste treatment/processing shall be consistent with the type of waste, decontamination, minimisation of secondary waste, storage needs, disposal/discharge option, and environmental safety requirements.

4.7 Conditioning

Conditioning of radioactive waste includes operation such as immobilisation and packaging. Conditioning process with compatible matrix shall be selected to obtain a waste product to meet acceptance criteria at subsequent steps. Appropriate contingency plans shall be in place for non-conforming waste packages.

4.8 Solid and Liquid Waste Storage Facilities

4.8.1 The design, construction, operation and maintenance of storage facilities shall provide for safe retrieval of waste. The capacity of the radioactive waste storage facility shall be designed on the basis of normal operation and anticipated operational occurrences. Other considerations such as seismic, tsunami, flooding and man induced events shall also be taken into account wherever necessary. The adequacy of the facility shall be reviewed from time to time with reference to capacity and expected life. Provisions for facilitating augmentation of the storage system shall be incorporated.

4.8.2 The solid waste storage system shall provide features such as monitoring and surveillance, waste package identification, material handling, fire protection, inspection, repackaging, ventilation with off-gas treatment, access control and physical protection. Shielding, cooling and criticality safety shall also be provided wherever applicable.

4.8.3 The liquid waste storage system shall provide for monitoring volume and activity and shall have adequate off-gas cleaning provision. Additional features, if applicable, like criticality control, shielding, agitation, multiple barriers and cooling shall be provided.

4.9 Refurbishing and Revamping

Life enhancement/management activities of nuclear and radiation facilities including waste management facilities such as refurbishing/revamping shall require authorisation from the regulatory body. Before commencement of such activities, the facility shall ensure availability of adequate waste management provisions.

4.10 Emergency Preparedness Plan

Approved emergency preparedness plan shall be available in the facility to deal with emergency situation due to any incident/accident. The plan shall spell out different emergency situations (personnel, plant and site), action levels, remedial actions and protection measures to control/minimise/mitigate the impact of the emergency situation. Responsibilities of various agencies involved shall be clearly defined. Periodic exercises and reviews shall be held to identify deficient areas and to carry out required improvements to maintain emergency preparedness.

4.11 Decommissioning and Management of Resulting Waste

4.11.1 Decommissioning plan shall be developed for each nuclear and radiation facility at the design stage to show that the decommissioning can be accomplished safely after shutdown and closure of the facility. The decommissioning plan shall be reviewed regularly and modified suitably as required. The decommissioning plan shall take into account residual activity characterisation, decontamination and dismantling needs, waste management requirements, safety assessment, adequate trained manpower and necessary funding. Decommissioning of the facility shall be carried out after approval from the regulatory body.

4.11.2 Availability of necessary waste management facilities, including treatment, conditioning, storage and/or disposal shall be established to cope with the decommissioning waste before starting decommissioning activities.

5. NEAR SURACE DISPOSAL OF SOLID WASTE

5.1 General

5.1.1 Solid waste disposal deals with emplacement of waste in approved facilities. Disposal may be in a near surface disposal facility (NSDF) or a deep geological repository. The design, construction, operation and post-operation of the NSDF need to meet necessary safety requirements. Three phases associated with the lifetime of a NSDF are: pre-operational, operational and post-operational.

5.1.2 Radioactive solid waste suitable for near surface disposal is the waste containing short-lived radionuclides, which may have small concentrations of long-lived radionuclides within prescribed limits.

5.2 Siting

5.2.1 Siting of near surface disposal facilities shall be governed by the applicable requirements of AERB Code of Practice on Safety in Nuclear Power Plant Siting [7]. Any deviation from the code shall have approval of the regulatory body prior to commencement of construction. In case of NSDF co-located with other nuclear facilities, its suitability shall be established with necessary investigation.

5.2.2 Before design and construction of the NSDF, the waste manager shall acquire sufficient land for development of the facility to accommodate the estimated quantity of solid waste and considering the decommissioning and augmentation requirements.

5.2.3 The NSDF site/land shall have clear ownership title and be free from encumbrances.

5.2.4 Areas having high population density and abundant in natural resources shall be avoided for locating the NSDF. The land and groundwater utilisation point of the public shall have adequate distance from the facility to reduce the potential of radiological impact.

5.2.5 Site characteristics including geology, hydro-geology, geochemistry, tectonics (if applicable) and seismicity, surface processes, meteorology, climate and the impact of human activities important to safety shall be taken into account in the design of the NSDF. Provisions shall be made so that events like tsunami, flooding, erosion, landslides, weathering do not endanger the integrity of the NSDF. The site shall be drainable taking into account topographic and hydrological features to avoid potential for flooding of the facility.

5.2.6 Extreme meteorological conditions at the site shall be evaluated for their adverse impact on the NSDF. Consideration should also be given to possible climatic changes during the post-closure phase.

5.2.7 The NSDF site shall be located such that any activity like excavation that may be reasonably expected to take place at or near the site does not compromise the effectiveness of isolation capability of the facility.

5.3 Design and Construction

5.3.1 The NSDF for solid/solidified waste shall be designed based on multi-barrier approach to provide isolation of waste from the biosphere for few hundreds of years. The effective and safe isolation of waste depends on the performance of the overall disposal system, which comprises waste form, engineered barriers and geological environment.

5.3.2 NSDF shall be constructed as per the approved design and applicable code. It shall consider waste and waste form characteristics, package characteristics, land requirements, layout and size of the facility, engineered barriers, biological shields, backfill material, post-operational sealing and water proofing, monitoring provisions, auxiliary services systems and anticipated institutional controls.

5.3.3 Based on safety assessment of the site, the design and construction of NSDF shall consider the site burden/inventory of the waste, which may be disposed in the facility until its closure.

5.3.4 Good access routes shall be designed, constructed and maintained for transport of the waste to the disposal site.

5.3.5 The need for active maintenance during post-closure phase of the NSDF shall be minimised and it should be complemented by the natural characteristics of the site to reduce any environmental impact.

5.3.6 Provision of monitoring and surveillance during operation and post-closure phases for verification of containment capability shall be made. In case release of activity above the prescribed limits to the environment is detected, necessary remedial measures shall be taken to mitigate the effects.

5.4 Operation

5.4.1 Operation of NSDF such as waste emplacement, interim closure and sealing shall be carried out as per the procedure. Appropriate engineered barrier shall be used for disposal of different categories of waste packages.

5.4.2 Waste manager shall obtain authorised limits from the regulatory body for disposal of different categories of waste packages for surface dose, total activity, radionuclide content and total inventory of the site.

5.4.3 Disposal of radioactive solid waste in NSDF shall ensure that the radiation level and contamination of radionuclides in air, water and soil in and around the disposal facility are within the limits prescribed by the regulatory body.

5.5 Waste Acceptance Criteria for Disposal

5.5.1 Radioactive waste destined for disposal shall be processed in such a way that the resultant waste packages meet the acceptance criteria approved by the regulatory body. The waste generator/manager shall produce waste form/ waste packages to meet these criteria for NSDF. The acceptance criteria shall be developed based on generic studies and site specific safety assessments taking into account:

(a) radiological criteria;

(b) engineered/natural barriers for prevention of radionuclide migration;

(c) operational conditions;

(d) planned duration of isolation;

(e) planned duration of active/passive institutional control; and

(f) configuration and identification.

5.5.2 Waste forms and packages shall be characterised for ;

(a) radionuclide content;

(b) physical, chemical, biological and pyrophoric properties; and

(c) fire resistance.

5.5.3 Waste packages shall be compatible with handling and transportation. It shall carry a unique identification number for records and emplacement location in NSDF. The package shall also provide information of waste characteristics.

5.6 Final Closure

5.6.1 Final closure of the NSDF site shall be carried out only after prior approval from the regulatory body. Approved plan and procedure shall be used for final closure of the NSDF. The closure plan shall include an updated safety assessment based on the site and waste disposal data. It shall also describe control measures intended for the post-closure phase, including monitoring and surveillance programme and record keeping system.

5.6.2 The closure plan shall also include the collation of all the information recorded during the previous phases that might be necessary for potential corrective actions or for reassessing safety of NSDF if warranted in the future. Some of the information will also be necessary to ensure that future generations would know the existence of the site by providing markers.

5.7 Post-closure and Institutional Control

5.7.1 The organisation(s) responsible for the implementation of active or passive controls shall be clearly identified and shall have approval of the regulatory

body. The responsible organisation shall effect controls as defined in the closure plan to maintain the NSDF as per design intent.

5.7.2 Institutional control shall be provided for a specified period after closure of a NSDF to:

(a) prevent intrusion into the NSDF;

(b) prevent removal of, or interference with, the radioactive waste;

(c) minimise erosion due to weathering;

(d) monitor the performance of the NSDF as per design intent; and

(e) perform any remedial actions that may be required.

5.7.3 The maximum duration of institutional control that a waste generator/waste manager may take credit for, in the safety assessment, shall be with the concurrence of the regulatory body.

5.7.4 The institutional control is active or passive. The institutional control plan and duration shall have approval of the regulatory body. During active control, monitoring, surveillance, periodic inspection, maintenance of NSDF and access control shall be performed by the waste manager or a responsible agency authorised by the regulatory body. During passive control use of permanent markers, land use restrictions may have to be looked into by an authority entrusted with these tasks from time to time.

6. QUALITY ASSURANCE

6.1 General

6.1.1 Quality Assurance (QA) is necessary to provide adequate confidence that the objectives of waste management are being met. This needs to be established for all stages of radioactive waste management viz., siting, design, construction, commissioning and operational phases of waste management facilities, including disposal, closure and post-closure phases of all types of repositories. Implementation of quality assurance programme (QAP) necessitate requisite organisational structure, operator training, safety assessment and audit.

6.2 QA Management

The QA management needs to have a well-defined programme. It shall address the management elements necessary for its policy implementation including planning, scheduling of activities and resource considerations. All these shall be documented in the QAP plan and the results of these activities should be recorded. QAP plan comprising various elements shall have the approval of the regulatory body.

6.3 QA Requirements

Requirements for QA shall have, among others, the following elements:

6.3.1 Siting

A QA for all activities associated with siting of the waste management facility shall be established early in the siting process. It shall provide documentary evidence to illustrate that the necessary quality of data on the site has been achieved.

6.3.2 Design, Construction and Operation

The quality control process shall be adhered to during design, construction and operation of the waste management facility with special attention given to control of changes in waste characteristics, operating procedures and barrier design to ensure that they do not have unacceptable consequences on safety.

6.3.3 Process Conformance

QA shall be applied to the processing of waste to ensure that all waste acceptance criteria are met with respect to handling, transportation, storage and disposal. Prevention of non-conformance in waste packages should be emphasised, particularly for those activities that, if not performed properly, could lead to an irreversible non-conformance. This shall be achieved through implementation of a QAP for the following activities:

(a) waste characterisation;

(b) development of waste package specifications;

(c) approval of conditioning process;

(d) verification of package characteristics; and

(e) review of quality control records.

6.3.4 Waste Acceptance

Waste generator shall provide the documentation necessary to comply with the waste manager's requirements with respect to the nature and the proper performance of any treatment, determination of radionuclide content, preparation of consignment or other actions that could affect the safety of disposal. The waste manager shall review the quality of information and QA provided by the waste generator so as to ensure acceptable characteristics of the waste.

6.3.5 Near Surface Disposal Facility

A QA programme shall be developed and applied to structures, systems, components and activities related to the near surface disposal of radioactive solid waste and also for the closure and post-closure of the repository. This programme shall provide for the collection and preservation of all the information recorded during the previous phases that could be important for safety in the future. This should also include long-term plans such as institutional control and site remediation activities.

6.3.6 Decommissioning

Accurate and complete information concerning locations, configurations, quantities and types of radionuclides remaining in the facility shall be acquired and maintained, for final dismantling. These records are to be used to demonstrate that all radioactive materials, which were present at the beginning of the decommissioning, have been properly accounted and their ultimate destinations and uses have been identified. This documentation is also to account for materials, structures and land that have been removed from regulatory control.

6.3.7 Organisational Structure

Waste management organisational structure shall provide for sufficient independence of the quality assurance function from the operation. The responsibilities and authority of personnel involved in QAP should be delineated. The waste manager shall have the primary responsibility for establishing and implementing an effective QAP, with a graded approach, covering all work associated with radiation protection and waste management that has a bearing on safe operation of the facility. The waste manager may

delegate to other organisations the work of establishing and implementing all or part of the programme, but shall retain responsibility for its overall effectiveness, without prejudice to the contractor's obligations and legal responsibilities.

6.3.8 Training of Personnel

Suitable training programme shall be devised for new as well as existing staff. The training programme should include fundamental and practical aspects of health care, safety and radiation protection, regulatory requirements, waste characterisation aspects and quality control steps and operational procedures relevant to their role in the management of radioactive waste. Refresher training shall be provided periodically and/or whenever procedures are revised.

6.3.9 Safety Assessment

The QAP shall include the assessment of health and safety performance through quality control, inspections of facilities and processes to minimise the occurrence of accidents/incidents. When changes are effected to operational procedures or regulatory requirements, safety assessment shall be reviewed to ensure that potential impact has not increased as a result of the changes introduced. Intrinsic and desired properties that need to be qualified, monitored or otherwise assured shall be assessed for each management step, mainly concerning safety of operating personnel, security of waste from interference and behaviour of the packaging under possible abnormal conditions.

6.3.10 Audits

Auditing shall be undertaken to ensure that there is adequate adherence to established procedures, instruction, specifications, codes, standards, administrative or operational programme and other applicable documents. The implementation and effectiveness of the QA may be best verified through the system audits, process audits, product audits and disposal audits.

6.3.11 Quality Control (QC)

Quality control involves the operational techniques and activities aimed at monitoring and recording all the essential requirements. It shall be based on the control of each element of the waste management process such as waste characteristics and their verification, accuracy and reliability of instruments, measuring techniques, process control parameters, identification and confirmation of the radioactive waste package prior to transfer/disposal.

7. DOCUMENTATION AND RECORDS

7.1 General

The waste generator/manager needs to maintain documents and records of radioactive waste generation and management consistent with the regulatory requirements. A comprehensive record system is required for regulating radioactive waste management practices**.** The records contain information on siting, design, construction, commissioning, operation and all phases of disposal including closure and post-closure of a waste management facility, decommissioning of nuclear facility and management of resulting waste**.**

7.2 Types of Records

7.2.1 The waste generator/manager shall maintain the following types of records:

(a) site plans, engineering drawings, specifications and process descriptions;

(b) authorisation of the facility including testing, commissioning, operation and modifications, if any;

(c) inventory of radioactive waste, including origin, location, physical and chemical characteristics of radioactive waste transferred or disposed from a facility;

(d) effluent discharges and environmental monitoring;

(e) safety and environmental assessment methods and associated computer codes;

(f) results of safety and environmental assessments;

(g) data pertaining to QA, Audits and QC;

(h) records of personnel radiation exposure and health history of occupational workers;

(i) incident/accident report and their remedial actions;

(j) training and qualification of personnel related to all processes, stages and phases;

(k) regulatory inspection;

(l) information about facility decommissioning/site remediation; and

(m) surveillance data of the repository during pre-operational, operational and post-closure phases including active and passive institutional control**.**

7.3 Retention of Records and Transfer of Information

7.3.1 Records pertaining to waste disposed in NSDF shall be maintained till the activity level reaches below the regulatory concern. Designated body shall take the responsibility for the retention of records and their maintenance in multiple retrievable forms/places. Security during retention and disposal of records shall be ensured.

APPENDIX- A

SPECIFIC REQUREMENTS IN THE MANAGEMENT OF RADIOACTIVE WASTE ARISING FROM THE USE OF SEALED /UNSEALED SOURCES IN MEDICINE, INDUSTRY AND RESEARCH

A.1 General

The requirements for the management of radioactive waste presented in the code are to be complied with, as applicable in the management of radioactive waste arising from the use of sealed/unsealed sources in medicine, industry and research. In addition some specific requirements are provided in this Appendix considering the special nature of the waste arising from such applications.

A.2 Responsibilities of Radiation Facility User/ Source Supplier

Various organisations involved in the management of radioactive waste generated in the use of radionuclides in medicine, industry and research are the supplier (source supplier), the waste generator (user), the authorised waste management agency (waste manager) and the regulatory body. There shall be coordination among all these agencies with the primary objective that radioactive waste does not cause undue hazard to the public. At the end of the useful life of the facility or its closure and upon relinquishment of the sealed/ unsealed sources, the facility shall be safely decommissioned and waste handed over to the authorised waste management agency (waste manager).

A.3 Unsealed Sources

(a) Radioactive waste generated during the use of unsealed sources in nuclear medicine or research applications shall be disposed of in approved waste disposal facilities at the work place of the institution as authorised by the regulatory body. Mixed waste with potential non-radiological hazard such as pathogenic infection, chemical toxicity shall be handled in accordance with regulations in force. Transfer of waste to another agency, if necessary, shall be undertaken only after obtaining approval from the regulatory body; and

(b) empty packages used for radioactive material including vials, card board boxes, tin containers, wooden boxes if required to be disposed off as normal waste, shall be made free from all type of contamination, radiation symbols and transport labels.

A.4 Sealed Spent/Disused Sources

(a) licensee/consentee shall not dispose off the sealed spent/unused source at the site. These sources shall be properly packed and transported to the supplier or waste disposal agency after obtaining permission from the competent authority/regulatory body;

(b) the spent/unused sources shall be checked for their integrity with respect to contamination prior to preparation of waste package for transport. Package shall be prepared, marked, labeled and transported as per the existing transport regulations for the safe transport of radioactive material;

(c) characterisation of spent sealed source including radionuclide content and inventory shall be provided;

(d) contaminated parts of the equipment or installation, if any, shall be adequately contained and packed separately; and

(e) an exclusive safe and secured facility shall be provided for temporary storage of decommissioned sources pending their transfer to the concerned agency.

APPENDIX-B

SPECIFIC REQUIREMENTS IN THE MANAGEMENT OF WASTES FROM THE MINING AND MILLING OF URANIUM AND THORIUM ORES

B.1 General

Radioactive and chemical wastes arise from various stages of mining and milling of uranium and thorium ores in the nuclear fuel cycle. Similar wastes may be generated outside the nuclear fuel cycle activities by the processing of raw substances containing naturally occurring radioactive materials (NORMs) or TENORMs (technologically enhanced NORMs) such as phosphate ore processing, oil and gas exploration etc. All such waste have large volumes with long lived natural radionuclides at very low concentrations. These wastes require specific management approach, which may deviate from the requirements given in the sections 4 and 5.

B.2 Solid Waste

B.2.1 Waste rocks and coarse tailings shall be preferably disposed into mined out areas to maintain ecological balance if the hydrological, engineering, radiation protection, environmental and economic aspects are favourable.

B.2.2 Waste retention system (slime dam, waste rock or heap leach piles) shall be constructed to retain the waste material taking into account site mineralogy, fault zones and seismicity.

B.2.3 Waste retention system and waste rock piles shall be stabilised in an appropriate manner so as to preclude wind and water erosion resulting in release of waste materials in excess of applicable approved standards. Stabilised areas shall be protected against run-off from surrounding drainage areas by provision of diversion channels. Consideration shall be given to potential effects of precipitation on the integrity of the stabilised area and possible seepage from there.

B.2.4 Stabilised areas shall be controlled and posted so as to restrict public access and habitation and prevent the unauthorised use of tailings/ waste rocks. In adjacent environs accessible to the general public, radiation levels and radon emanation from the stabilised waste materials shall not exceed applicable limits. A surveillance and monitoring programme shall be established to determine environmental concentrations of radioactive and other waste materials.

B.2.5 Waste rock piles and waste retention system shall be left in a completely stable form so that they blend aesthetically with the general landscape. The

piles may be released for unrestricted use after clearance from the regulatory body based on safety assessment.

B.3 Liquid Waste

Liquid waste such as drainage/seepage from mines, washes/rinses of heap piles, slime dam decants shall be monitored, characterised and treated. These wastes shall be recycled to the mine/mill or discharged to a waste retention system within the prescribed limits.

B.4 Gaseous Waste

B.4.1 Exhaust ventilation from underground mines and processing units shall be controlled within the prescribed limits of radon/ thoron and its daughter products.

B.4.2 The release of dust and fumes from mining, milling, processing and storage operations shall be controlled by appropriate methods to keep the releases within the prescribed limits.

APPENDIX-C

SITE REMEDIATION

C.1 General

C.1.1 Remediation measures of a contaminated land/site shall be adopted for progressive reduction of hazard by removal of radionuclide contamination and/or stabilisation of the site with the intention of eventual removal of regulatory control of the contaminated land/site.

C.1.2 The required level of remediation shall be established on a site specific basis and in accordance with radiation protection requirements that apply to intervention situations and shall be justified and optimised.

C.1.3 The management of waste resulting from land/site remediation shall be carried out in accordance with the requirements specified in this document.

C.2 Remediation Plan

An agency shall be identified for carrying out the site remediation activities as per the approved plan. After completion of the remediation activities the agency shall submit a report to the regulatory body for review. Remediation plan shall be implemented through the following stages:

(a) develop remediation strategy taking into account: nature of problem; relevant information concerning the past and present management of the situation; response actions taken in the past;

(b) assess both the radiological and non-radiological impacts of the situation and the benefits and detriments associated with possible remedial measures, including the associated restrictions and institutional arrangements;

(c) prepare a remediation plan for each contaminated area identifying the goal for remediation, reference levels for remediation, the nature, scale and duration of the remedial measures to be implemented. The plan should consist of elements such as technique to be used for decontamination, radionuclide immobilisation (stablisation, strengthening of barrier backfill, top soiling for dose reduction, management of contaminated vegetation etc.);

(d) identify the waste disposal or storage site, as appropriate;

(e) identify any post-remediation restrictions, the monitoring and surveillance programmes and arrangements for institutional control for the remediated area;

(f) establish and maintain arrangements for emergency planning commensurate with the hazards associated with the remediation activities;

(g) show that remediation may be accomplished safely and get the scheme of remediation approved by the regulatory body prior to its implementation;

(h) report incidents significant to safety to the regulatory body in a timely manner;

(i) verify that the remediation measures meet the established criteria set by the regulatory body

C.3 Completion of Remediation

The completion report of remediation carried out by the designated agency as per the approved plan shall be submitted to the regulatory body for approval. Completion report shall include following information:

(a) identification of the waste disposal or storage site, as appropriate;

(b) effectiveness of remediation carried out;

(c) radiation exposure to workers; and

(d) management (stabilisation/ immobilisation) of waste generated.

APPENDIX-D

WASTE TRANSPORT/ TRANSFER

D.1 General

Transport of liquid and solid waste requires appropriate system for safe handling at consignor's and consignee's premises. It involves use of specified procedures and control measures, including documentation of the waste transported. The transport system may be required on-site/off-site.

D.2 On-site and Off-site Transport

D.2.1 On-site transport of radioactive waste shall be carried out as per the approved procedure. The off-site transport of radioactive waste shall be governed by AERB transport code [8]. Any deviation from the above shall have prior approval of the regulatory body.

D.2.2 Adequate security shall be provided during off-site transportation/ transfer of radioactive waste to ensure safety incase of any untoward incident.

D.2.3 Adequate packaging, shielding and supervision shall be provided to keep the radiation exposure to personnel minimum and also to minimise the potential for the release of radioactive material in the event of a transport accident.

D.2.4 Prior to the dispatch of package(s) or the departure of vehicle carrying packaged material, the consignor shall ensure that the radiation levels and surface contamination are within the limits prescribed by the regulatory body.

D.2.5 The consignor (sender) shall have the responsibility for safe transport of radioactive waste through the public domain. It should include among others safety of the package, control during transportation and necessary instructions in the event of emergency situation.

D.2.6 On-site/ off-site transport of large quantities of radioactive material generated from site remediation or any incident/accident shall be carried out after obtaining necessary clearances from the regulatory body.

D.2.7 Approved procedure for transport of radioactive waste shall include, among others, tie down arrangement, health physics coverage and qualified crew.

D.3 Liquid Waste Transport/ Transfer

Design and operation of different modes of liquid waste transport/transfer shall, among others, take following specific requirements into account.

D.3.1 Tanker/Container transport:

(a) Transport as per approved procedures, including display of radiation symbols;

(b) Adequate provisions for shielding, cooling, secondary containment, pressure relieving systems, as applicable;

(c) Adhering to prescribed activity limits and safe waste levels;

(d) Providing the consignor with action plan for accidental and vehicle breakdown scenarios; and

(e) Material selection based on compatibility with waste characteristics and provision for leakage control/collection/monitoring.

D.3.2 Transfer through Outdoor Pipeline

The integrity and performance of the piping system shall be ensured through design with considerations for material compatibility, multi-barriers, piping redundancy, shielding, leakage prevention/detection and physical isolation/protection. Periodic testing, inspection and maintenance programme shall be developed to ensure safe operation of the transfer system. A graded design/operational approach should be adopted based on safety analysis.

D.4 Solid Waste Transport

D.4.1 The waste packages shall be classified and tested as per the AERB transport code.

D.4.2 The solid radioactive material shall be transported in a packaged form taking into account the following aspects:

(a) containment;

(b) shielding;

(c) classification of package;

(d) heat dissipation (applicable to high activity radioactive materials); and

(e) criticality safety, if applicable.

ANNEXURE-I

PRINCIPLES AND PHILOSOPHY OF RADIOACTIVE WASTE MANAGEMENT

Principles

Principles of radioactive waste management are important aspects for the development of safety requirements. Applications of these principles will ensure adequate safety in the management of radioactive waste [9]. These principles are:

Principle 1: Protection of Human Health and Environment

Radioactive waste shall be managed in such a way as to provide an acceptable level of protection for human health and the environment.

Principle 2: Concern for Future Generations

Radioactive waste shall be managed in such a way that it will not impose undue burden on future generations and its predicted impact on the health of future generations will not be greater than relevant levels of impact that are acceptable today.

Principle 3: Establishing Legal Framework

Radioactive waste shall be managed within an appropriate legal framework including clear allocation of responsibilities and provision for independent regulatory functions.

Principle 4: Waste Minimisation, Management Interdependency and Safety of Facilities

Generation of radioactive waste shall be kept to the minimum practicable. Interdependency among all steps in radioactive waste generation and management shall be taken into account. The safety of facilities for radioactive waste management shall be assured during their lifetime.

Philosophy

The general philosophy for radioactive waste management being followed is given below:

(a) Delay and decay of short-lived radionuclides;
(b) Concentrate and contain activity as practicable; and
(c) Dilute and disperse low-level radioactive waste within the authorised limits.

The resulting basic steps in the management of radioactive waste from pre-treatment to disposal are covered in Annexure II.

ANNEXURE-II

BASIC STEPS IN RADIOACTIVE WASTE MANAGEMENT

This Annexure describes the various steps in radioactive waste management in order to provide a common terminology and understanding among authors, reviewers and users of AERB/RW (Radwaste Series) documents. The descriptions presented herein are intended to be general and apply to the management of radioactive waste from mining and milling, fuel fabrication, nuclear power generation, production and application of radioactive materials in medicine, industry, agriculture and research and environmental restoration. They apply to radioactive waste generated during the operational period as well as during the decommissioning of a facility. The applicability of these steps will vary depending on the type of radioactive waste.

Effective management of radioactive waste encompasses the basic steps (shown schematically in Fig. A.1) in the radioactive waste management process as parts of a total system, from generation through disposal. As decisions made in one step may foreclose certain alternatives in another step, the radioactive waste management programme emphasises the importance of taking into account interdependencies among all steps during planning, design, construction, operation and decommissioning of radioactive waste management facilities.

The waste should be characterised in order to determine its physical, chemical and radiological properties, and to facilitate record keeping and acceptance of radioactive waste from one step to another. Characterisation may be applied in order to segregate radioactive waste for exemption, reuse, disposal methods or to assure compliance of waste packages with requirements for safe storage and disposal.

It should also be noted that transportation may be necessary between the radioactive waste management steps. Effective radioactive waste management should take the requirements of safe transportation into account.

Storage of radioactive waste involves maintaining the radioactive waste such that: (i) isolation, environmental protection and monitoring are provided; and (ii) actions involving, for example, treatment, conditioning and disposal are facilitated. In some cases, storage may be practiced for primarily technical considerations, such as storage of radioactive waste containing mainly short lived radionuclides for decay and subsequent release within authorised limits, or storage of high level radioactive waste from thermal considerations prior to geological disposal. In other cases, storage may be practiced for reasons of economics or policy.

Pre-treatment of waste is the initial step in waste management that occurs after waste generation. It consists of, for example, collection, segregation, chemical adjustment and decontamination and may include a period of interim storage. This initial step is extremely important because it provides in many cases the best opportunity to segregate

waste streams, for example, for recycling within the process or for disposal as ordinary non-radioactive waste when the quantities of radioactive materials they contain are exempt from regulatory controls. It also provides the opportunity to segregate radioactive waste, for example, for near surface or geological disposal.

Treatment of radioactive waste includes those operations intended to improve safety or economy by changing the characteristics of the radioactive waste. The basic treatment concepts are volume reduction, radionuclide removal and change of composition. Examples of such operations are: incineration of combustible waste or compaction of dry solid waste (volume reduction); evaporation, filtration or ion exchange of liquid waste streams (radionuclide removal); and precipitation or flocculation of chemical species (change of composition). Often several of these processes are used in combination to provide effective decontamination of a liquid waste stream. This may lead to several types of secondary radioactive waste to be managed (contaminated filters, spent resins, sludges).

Conditioning of radioactive waste involves those operations that render the waste into a form suitable for handling, transportation, storage and disposal. The operations may include immobilisation of radioactive waste, placing the waste in containers and providing additional packaging. Common immobilisation methods include solidification of low and intermediate level radioactive waste in cement or polymer, and vitrification of high-level liquid radioactive waste in a glass matrix. Immobilised waste, in turn, may be packaged in containers ranging from common 200 litre steel drums to highly engineered thick-walled containers, depending on the nature of radionuclides and their concentrations. In many instances, treatment and conditioning take place in close conjunction with one another.

Disposal is the final step in the radioactive waste management system. It consists mainly of the emplacement of radioactive waste in a disposal facility with reasonable assurance for safety, without the intention of retrieval and without reliance on long-term surveillance and maintenance. The safety is mainly achieved by isolation of suitably conditioned radioactive waste in a disposal facility. Isolation is attained by placing barriers around the radioactive waste in order to restrict the release of radionuclides into the environment. The barriers can be either natural or engineered and an isolation system can consist of one or more barriers. A system of multiple barriers gives greater assurance of isolation and helps ensure that any release of radionuclides to the environment will occur at an acceptably low rate. Barriers can either provide absolute containment for a period of time, such as the metal wall of a container, or may retard the release of radioactive materials to the environment, such as a backfill or host rock with high sorption capability. During the period when the radioactive waste is contained by the system of barriers, the radionuclides in the waste are undergoing decay thereby reducing the radiation hazard with time. The barrier system is designed according to the disposal option chosen and the radioactive waste forms involved.

Although it is planned to dispose off most types of radioactive waste by concentration and containment, disposal may also comprise the discharge of effluents (for example, liquid and gaseous waste) into the environment within authorised limits, with subsequent dispersion.

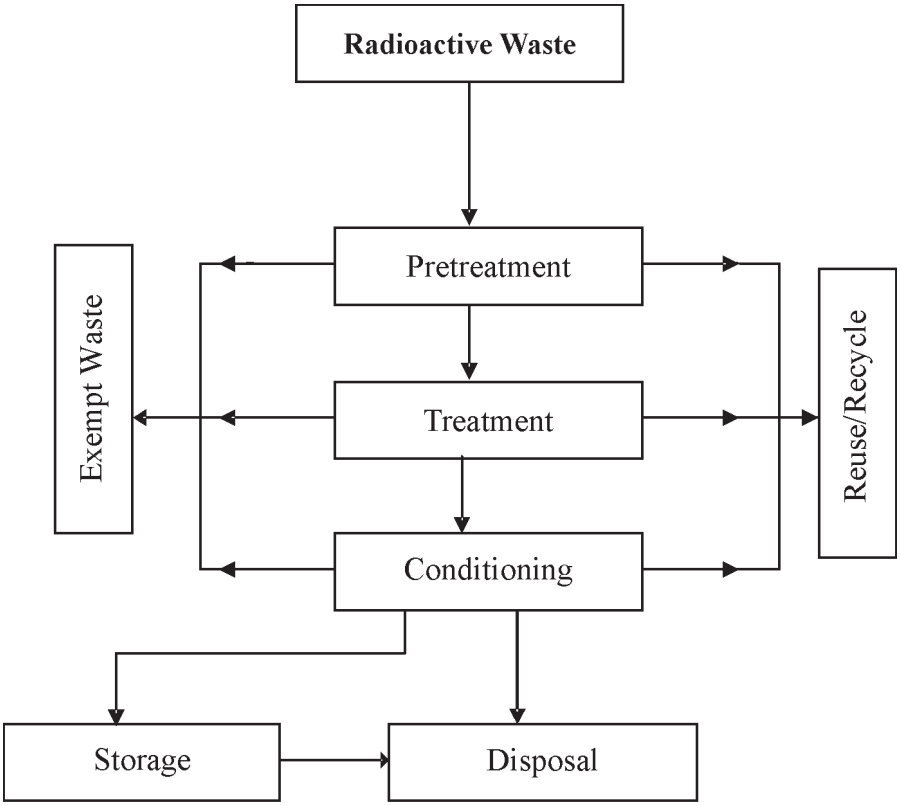


FIG. A-1: BASIC STEPS IN RADIOACTIVE WASTE MANAGEMENT

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Shri S.Vedamurthy	:	NPCIL (Invitee)
Dr. P.Vijayan (Member-Secretary)	:	AERB

ADVISORY COMMITTEE ON NUCLEAR SAFETY (ACNS)

Date of meeting	:	November 14, 2003
	:	July 10, 2006

Members of ACNS:

Shri G.R. Srinivasan (Chairman)	:	AERB (Former)
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PROVISIONAL LIST OF SAFETY CODE AND GUIDES ON RADIOACTIVE WASTE MANAGEMENT FOR NUCLEAR AND RADIATION FACILITIES

Safety Series No.	Title
AERB/NRF/SC/RW	Management of Radioactive Waste.
AERB/SG/RW-1	Classification of Radioactive Waste.
AERB/SG/RW-2	Predisposal Management of Low and Intermediate Level Radioactive Waste.
AERB/SG/RW-3	Pre-disposal Management of High Level Radioactive Waste.
AERB/SG/RW-4	Near Surface Disposal of Radioactive Solid Waste.
AERB/NF/SG/RW-5	Management of Radioactive Waste from Mining and Milling of Uranium and Thorium
AERB/RF/SG/RW-6	Management of Spent Radiation Sources and Radioactive Waste arising from the use of Radionuclides in Medicine, Industry and Research including Decommissioning of such facilities.
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AERB/SG/D-13	Liquid and Solid Radwaste Management in Pressurised Heavy Water Reactor Based Nuclear Power Plants.

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