GUIDELINES NO. AERB/NPP/SG/O-11

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GOVERNMENT OF INDIA

AERB SAFETY GUIDE

# MANAGEMENT OF RADIOACTIVE WASTE ARISING FROM OPERATION OF PRESSURISED HEAVY WATER REACTOR BASED NUCLEAR POWER PLANTS

ATOMIC ENERGY REGULATORY BOARD

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# MANAGEMENT OF RADIOACTIVE WASTE ARISING FROM OPERATION OF PRESSURISED HEAVY WATER REACTOR BASED NUCLEAR POWER PLANTS

**Atomic Energy Regulatory Board**
**Mumbai - 400 094**
**India**

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**Administrative Officer**
**Atomic Energy Regulatory Board**
**Niyamak Bhavan**
**Anushaktinagar**
**Mumbai-400 094**
**India**

# 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 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 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, codes of practice and related guides and manuals for the purpose. These documents cover aspects such as siting, design, construction, operation, quality assurance, decommissioning and regulation of nuclear and radiation facilities.

Codes of practice and safety standards are formulated on the basis of internationally accepted safety criteria for design, construction and operation of specific equipment, systems, structures, components of nuclear and radiation facilities. Safety codes establish the 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.

The code of practice on 'Safety in Nuclear Power Plant Operation' (AERB/SC/O) states the minimum requirements to be met during operation of nuclear power plants in India. This guide is based on the current practices followed in Pressurised Heavy Water Reactors (PHWRs) and also Boiling Water Reactors (BWRs) for assuring safety. It specifically provides guidance on all aspects of management of radioactive waste arising from operation of nuclear power plants (predominantly PHWRs) and also for implementing the relevant parts of the code of practice on 'Safety in Nuclear Power Plants Operation', published byAERB. In drafting this guide, the relevant International Atomic Energy Agency (IAEA) documents under the Nuclear Safety Standards (NUSS) programme, especially the safety guide on 'Management of Radioactive Waste and Effluents Arising During Nuclear Power Plants' (No. 50-SG-O-11, 1984) and other international documents have been used extensively.

Consistent with the accepted practice, 'shall', 'should' and 'may' are used in the guide to distinguish between a firm requirement, a recommendation and a desirable option, respectively. Appendices are an integral part of the document, whereas annexures, footnotes, references/ bibliography and lists of participants are included to provide information that might be helpful to the user. Approaches for implementation different

To those set out in the guide may be acceptable, if they provide comparable assurance against undue risk to the health and safety of the occupational workers and the general public, and protection of the environment.

For aspects not covered in this guide, applicable and acceptable national and international standards, codes and guides should be followed. Non-radiological asepcts of industrial safety and environmental protection 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.

This guide has been prepared by specialists in the field drawn from the Atomic Energy Regulatory Board, Bhabha Atomic Research Centre and Nuclear Power Corporation of India Limited 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 affiliation, is included for information.

(Suhas P. Sukhatme)
Chairman, AERB

## DEFINITIONS

**Acceptable Limits**

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

**Accident Conditions**

Substantial deviations from operational states, which could lead to release of unacceptable quantities of radioactive materials. They are more severe than anticipated operational occurrences and include design basis accidents as well as beyond design basis accidents.

**Anticipated Operational Occurrences**

An operational process deviating from normal operation, which is expected to occur during the operating lifetime of a facility but which, in view of appropriate design provisions, does not cause any significant damage to items important to safety, nor lead to accident conditions.

**Approval**

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

**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 nuclear and radiation facility and to perform safety and regulatory functions, including enforcement for the protection of site personnel, the public and the environment against 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.

**Certification (of Personnel)**

The formal process of certifying personnel by an authority for performing the various activities in nuclear and radiation facilities.

**Commencement of Operation of NPP**

The specific activity, activities in the commissioning phase of a nuclear power plant towards first approach to criticality, starting from fuel loading.

**Commissioning**

The process during which structures, systems and components of a nuclear and radiation facility, on being constructed, are made functional and verified in accordance with the design specifications and to have met the performance criteria.

**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.

**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.

**Discharge (Radioactive)**

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

**Discharge Limits**

The limits prescribed by the regulatory body for effluent discharges into atmosphere aquatic environment from nuclear/radiation facilities.

**Disposal (Radioactive waste)**

The emplacement of waste in a repository without the intention of retrieval or 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.

**Commissioning**

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**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.

**Item**

A general term covering structures, systems, equipment, components, parts or materials.

**Licence**

A type of regulatory consent, granted by the regulatory body for all sources, practices and uses of 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 (see 'Licenced Person' and 'Licenced Position').

**Licenced Person**

A person who has been licenced to hold certain licenced positions of a nuclear power plant after due compliance with authorised procedure of certification by the regulatory body.

**Licenced Position**

A position, which can be held only by persons certified by the regulatory body or a body, designated by it.

**Monitoring**

The continuous or periodic measurement of parameters for reasons related to determination, assessment in respect of structure, system or component in a facility or control of radiation.

**Normal Operation**

Operation of a plant or equipment within specified operational limits and conditions. In case of a nuclear power plant this includes startup, power operation, shutting down, shutdown state, maintenance, testing and refuelling.

**Nuclear Power Plant (NPP)**

A nuclear reactor or a group of reactors together with all the associated structures, systems and components necessary for safe generation of electricity.

**Nuclear Safety**

The achievement of proper operating conditions, prevention of accidents or mitigation of accident consequences, resulting in protection of site personnel, the public and the environment from undue radiation hazards.

**Operation**

All activities followed and prior to commissioning performed to achieve, in a safe manner, the purpose for which a nuclear/radiation facility is constructed, including maintainance.

**Operational Limits and Conditions (OLCs)**

Limits on plant parameters and a set of rules on the functional capability and the performance level of equipment and personnel, approved by the regulatory body, for safe operation of the nuclear/radiation facility.

**Operating Organisation**

The organisation so designated by responsible organisation and authorised by regulatory body to operate the facility.

**Operating Personnel**

Members of site personnel who are involved in operation of the nuclear radiation facility.

**Operational Records**

Documents such as instrument charts, certificates, log books, computer printouts and magnetic tapes, made to keep objective history of the operation of nuclear/radiation facility.

**Operational States**

The states defined under 'Normal Operation' and 'Anticipated Operational Occurrences'.

**Plant Management**

Members of the site personnel who have been delegated responsibility and authority by the operating organisation for directing the operation of the plant.

**Prescribed Limits**

Limits established or accepted by the regulatory body.

**Qualified Person**

An individual who, by virtue of certification by appropriate authorities and through experience is duly recognised as having expertise in a relevant field of specialisation like quality assurance, radiation protection, plant operation, fire safety or any relevant engineering or safety speciality.

**Quality Assurance**

Planned and systematic actions necessary to provide the confidence that an item or service will satisfy the given requirements for quality.

**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.

**Radiation Safety**

(see 'Nuclear Safety' )

**Regulatory Body**

(see 'Atomic Energy Regulatory Board' )

**Regulatory Consent**

(see 'Consent' )

**Regulatory Inspection**

An examination through review of documents, observation, measurement or test undertaken by or on behalf of the regulatory body during any stage of the regulatory consenting process, to ensure conformance of materials, components, systems and structures as well as operational and maintenance activities, processes, procedures, practices and personnel competence with predetermined requirements.

**Responsible Organisation**

An organisation having overall responsibility for siting, design, construction, commissioning, operation and decommissioning of a facility.

**Safety**

(see 'Nuclear Safety' )

**Safety Limits**

Limits upon process variables within which the operation of the facility has been shown to be safe.

**Safety Report**

A document provided by the applicant or licensee to the regulatory body, containing information concerning the facility, its design, accident analysis and provisions to minimise the risk to the public, and to the site personnel.

**Safety Support System**

Part of safety systems which encompasses all the equipment that provide services, such as cooling, lubrication and energy supply (pneumatic or electric) required by the protection system and safety actuation systems.

**Safety System**

Systems important to safety and provided to assure that under anticipated operational occurrences and accident conditions, the safe shutdown of the reactor followed by heat removal from the core and containment of any radioactivity, is satisfactorily achieved. (Examples of such systems are shutdown systems, emergency core cooling system and containment isolation systems). It is also called as 'safety critical system'.

**Secondary Waste**

A form and quantity of waste that results as a by-product of the process from applying a waste treatment technology to the initial waste.

**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.

**Site**

The area containing the facility defined by a boundary and under the effective control of the facility management.

**Site Personnel**

All persons working on the site, either permanently or temporarily.

**Solidification (Radioactive Waste)**

Immobilisation of gaseous, liquid-like materials by conversion into solid waste form usually with the intent of producing a physically stable material that is easier to handle and less dispersable. Calcination, drying, cementation, bituminisation and vitrification are some of the typical ways of solidifying liquid radioactive waste, (see also 'Conditioning of Waste' ).

**Specification**

A written statement of requirements to be satisfied by a product, a service, a material or process, indicating the procedure by means of which it may be determined whether the specified requirements are satisfied.

**Storage (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 performed to ensure compliance with specifications established in a facility.

**Technical Specifications for Operation**

A document approved by the regulatory body, covering the operational limits and conditions, surveillance and administrative control requirements for safe operation of the nuclear or radiation facilities. It is also called 'Operational Limits and Conditions'.

**Waste Management**

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

**Waste Management Plant**

All facilities dealing with activities involving waste management such as, handling, treatment, conditioning and transportation.

**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.

## CONTENTS

# 1. INTRODUCTION

## 1.1 General

Radioactive waste generated from the operation of nuclear power plants (NPPs) has to be managed in a safe manner. This safety guide covers aspects regarding management of radioactive waste arising from all operational states and other special activities, for compliance with the requirements specified by AERB.

## 1.2 Objectives

1.2.1 The objectives of this safety guide are to provide guidance on safe handling, treatment, storage, transport and disposal of radioactive waste arising from operation of NPPs in line with the requirements spelt out in 'Code of Practice on Safety in Nuclear Power Plant Operation' (AERB code No. SC/O).

## 1.3 Scope

1.3.1 The scope of this safety guide includes the following:

i) requirements of on-site handling and management of radioactive waste, environmental monitoring and criteria for release of radioactivity into the environment,

ii) guidance on organisational aspects of waste management plant, and detailed aspects of the waste generation and control as applicable to different types of gaseous, liquid and solid waste, and

iii) information on the provisions needed by the operating organisation for monitoring, evaluating and controlling the release of radioactive effluents from the plant during its commissioning and operational phases and to demonstrate compliance with the requirements of AERB.

1.3.2 This safety guide primarily deals with the management of radioactive waste generated from operation of pressurised heavy water reactors (PHWRs) and due to other special activities carried out during lifetime of the plant. Guidance on the management of waste arising from activities such as coolant channel replacement, chemical decontamination of reactor system and waste generated on account of LOCA, have been discussed briefly. The guidance provided here may also be applicable for boiling water reactor (BWR ) waste. Typical information on BWR waste reduction and control measures is covered separately.

1.3.3 This safety guide does not cover handling of high level waste and large volume of waste arising from accident conditions such as large LOCA leading to closure of NPP. It also does not cover the management of waste arising from the decommissioning of NPPs, for which guidance has been provided in the AERB safety manual on 'Decommissioning of Nuclear Facilities' [9].

# 2. WASTE MANAGEMENT PROGRAMME REQUIREMENTS

## 2.1 General

The waste management programme is mainly based on radiological protection requirements. The overall objective is to manage radioactive waste in a manner which ensures that radiation exposure to the operating personnel, the members of the public, and the environment are within the prescribed limits as specified by AERB. It is therefore imperative that the operating organisation/plant management shall establish a waste management programme to ensure that radioactive waste arising from the operation of NPPs is so managed that the above objective is fulfilled. The requirements for radioactive waste management are given below.

## 2.2 Radiological Protection Requirements for Personnel and Environment

2.2.1 The radiological protection objective in the management of radioactive waste is to keep the effective dose to individuals as low as reasonably achievable (ALARA).

2.2.2 All radiation exposures, both to occupational workers and members of public, shall not exceed the limits prescribed by AERB.

2.2.3 Derived limits (DLs) for radioactive releases to the environment through air, land and water routes shall be developed for a site as per AERB guidelines.

2.2.4 For a multi-unit facility site, unit-wise dose limit to members of public should be apportioned to each facility suitably as per AERB guidelines.

2.2.5 The waste disposal shall be within the limits prescribed by AERB.

2.2.6 A well defined radiological protection programme for waste management shall be established. Appropriate procedures for handling of radioactive waste shall be laid down, especially with respect to access control, ventilation control and shielding requirements.

2.2.7 Radiation and air monitoring requirements for various areas of the waste mangement plant shall be established.

2.2.8 Radioactive effluent discharges into the environment shall meet the requirements specified by AERB.

2.2.9 The radioactive waste management system operations shall comply with limiting conditions for operations as prescribed by AERB.

2.2.10 Provision of continuous sampling at main-out-fall (MOF), of surface and subsurface samples from bore holes around waste repository, environmental monitoring programme at the exclusion zone and beyond (viz. upto emergency planning zone), etc. shall be established.

2.2.11 Provisons for monitoring gaseous releases shall be made.

2.2.12 Comprehensive data collection and reporting system should be established for disposal of radioactive waste taking into account the AERB requirements.

## 2.3 Operational Requirements

2.3.1 A waste management plant (WMP) along with a near surface disposal facility shall be available, prior to the commencement of NPP operation.

2.3.2 Operational practices at NPPs and WMP shall ensure minimisation of waste generation in terms of both activity and volume.

2.3.3 Duly qualified and validated waste management processes and operations complying with relevant standards and criteria should be used to ensure adequacy and reliability of treatment, conditioning and disposal of radioactive waste.

2.3.4 The plant management should interact with the designer of WMP during the design and construction phase to ensure that the plant and associated facilities are capable of meeting the waste management objectives. This interaction should also be continued during the operational phase.

2.3.5 Approved operating procedures for handling, treatment, conditioning and disposal of radioactive waste shall be made available before commencement of operation of NPPs.

2.3.6 The plant management shall establish an organisational set up for the WMP clearly defining the work functions of various plant personnel. Appropriate training and qualification requirements for various positions of the waste management should be established.

2.3.7 The plant management shall also establish a system of generation, processing, storage and retrieval of data pertaining to collection, storage, transfer, treatment, conditioning and discharge/disposal of waste in a manner that facilitates periodic audit by AERB.

2.3.8 The plant management shall ensure that generation and handling of waste at the plant is according to the design intent of the NPP.

# 3. WASTE MANAGEMENT PLANT ORGANISATION

## 3.1 General

The chief of NPP plant management who is responsible for safety of the plant, personnel, public and environment shall ensure that a functional organisational structure is established with adequate manpower for the safe operation of the waste management facilities, with support from health physics unit and environmental survey laboratory.

## 3.2 Positions and Responsibilities

The WMP organisation should consist of a Head, WMP, assisted by O & M staff dedicated to WMP operations and Health Physicist. A typical functional organisation chart of WMP is given in Annexure-I.

3.2.1 Head, Waste Management Plant (HWMP):

The HWMP holds the overall responsibility for safe management of radioactive waste and in particular ensures:

i) Compliance with the technical specifications.

ii) Safe operation and maintenance of waste management plant and facilities.

iii) Availability and reliability of the WMP systems.

iv) Adequate system flexibility.

v) Availability of equipment decontamination facility for reuse and recycling of equipment and materials within the plant.

vi) Minimisation of secondary waste generation.

vii) Limiting the effect of significant risks (man-made and natural) identified in the safety analysis report.

viii) Application of ALARA principle to waste management practices.

ix) Effective control over generation and accumulation of waste.

x) Training of personnel.

xi) Adherence to correct operating and maintenance procedures.

xii) Good housekeeping.

xiii) Identification of sources and classifications of waste streams.

xiv) Segregation of waste streams.

xv) Timely reporting of information on effluents.

xvi) Effectiveness of waste treatment system to handle and treat waste arising from anticipated operational occurrences.

xvii) Information and data mentioned in the safety report are valid at all times, and implement any modifications to the same, if required with proper justification and necessary approval.

xviii) Monitoring the effectiveness of systems and components which serve as a barrier against the release of radioactivity.

xix) Minimisation of unusual occurrences in WMP.

xx) Periodic review of plant performance and plant data to identify the need for improving and incorporating changes.

xxi) Maintenance of records pertaining to receipt, storage, transfer, treatment, conditioning and disposal of radioactive waste as required by AERB.

3.2.2 Health Physicist:

Health Physicist assigned to WMP should ensure the following:

i) Availability of approved radiation protection manual containing relevant radiation protection procedures and radiation emergency procedures.

ii) Availability of change-room facility and shower facility.

iii) Availability of dose measurement facilities (both internal and external) of all personnel engaged in radiation work.

iv) Availability of area gamma monitors, contamination monitors and personnel monitors.

v) Availability of procedures to control radiation exposure taking into account ALARA principle.

vi) Periodic medical examinations and whole body monitoring of individals engaged in radiation work including casual/contract workers.

vii) Availability of facility for testing and calibration of radiation instruments, and periodic checking and calibration and inter-comparison of standards to ensure monitoring accuracy and precision of the radiation instruments.

viii) Adherence to radiological work permit system.

ix) Health physics coverage for all radiation related jobs.

x) Adherence to individual and collective dose limits.

xi) Maintenance of relevant records for individual and collective doses.

xii) Maintenance of relevant records for plant radiological conditions for future reference.

xiii) Periodic review of internal and external radiation exposures and investigation/reporting exposure cases exceeding prescribed limits.

xiv) Usage of release permit procedures.

xv) Coordination of radiological works with other agencies.

xvi) Availability of decontamination facilities for personnel.

xvii) Availability of chemical laboratory for radiochemical analysis.

xviii) Availability of air sampler, filter papers and associated counting setup.

xix) Availability of protective equipment (respirators, plastic suits, rubber shoes, etc.).

xx) Availability of caution boards-stickers, cordons to use wherever necessary.

xxi) Advice and consultation in certain activities for waste management such as decontamination, repair etc.

# 4. WASTE MANAGEMENT OPERATIONS

## 4.1 General

4.1.1 The objective of the waste management operations should be to operate and maintain the systems in accordance with the operational limits and onditions as specified in the technical specifications and authorisation granted by AERB. To achieve the overall objective of the waste management programme, the operator should operate and maintain the WMP in a manner to ensure:

i) proper treatment and conditioning of the waste;

ii) availability of sufficient waste storage capacity to meet additional waste arising from anticipated operational occurrences;

iii) effective control to minimise primary and secondary waste generation and its accumulation;

iv) long term safety of waste disposal;

v) application of ALARA principle to all waste management operations; and

vi) that radiation exposures to plant personnel and members of the public do not exceed the limits prescribed by AERB.

## 4.2 Management of Operations

4.2.1 Trained Manpower

Adequate supervision and control by trained personnel at all stages of waste management operations should be ensured. Operators should be trained and qualified as required.

4.2.2 Commissioning

The commissioning of the waste management systems should be carried out as per the approved commissioning procedures. This should outline schedules of verification, testing, and remedial and follow-up actions.

4.2.2.1 The commissioning process should verify that:

i) the construction had proceeded according to the approved plans and drawings;

ii) the performance of individual components and the systems as a whole meet the design intent;

iii) the operations and processes are capable of providing treated and conditioned waste and waste forms/packages with the desired characteristics as indicated in the safety report for the WMP; and

iv) the results of verification testing meet the system/equipment acceptance criteria. These should be documented along with design specifications and 'as - built drawings'. Followup actions should also be documented.

4.2.3 Waste Acceptance Criteria

Waste acceptance criteria for treatment, conditioning and disposal of radioative waste are important aspects of waste management. Effectiveness of the waste treatment and of conditioning process depends to a large extent on the characteristics of the waste received. Waste treatment plant should have the capability to take care of any waste being generated during normal operation of the NPP which are within the operational parameters of the WMP. However, for any waste that is to be treated beyond the operating parameters of the WMP, each type of waste should be considered on a case by case basis.

4.2.3.2 The waste acceptance criteria should be established taking into account the identified limits and conditions of operations and pre-defined characteristics of the waste forms/packages and the disposal facility at the site. It should also indicate the acceptable chemical, radio-chemical, physical and mechanical characteristics.

4.2.3.3 The waste acceptance criteria should be documented and shall be adhered to.

4.2.4 Operating Procedures/Documents

4.2.4.1 Operations of the waste management systems should be carried out as per the approved procedures.

4.2.4.2 Approved documents should be made available before commencement of WMP operations. These should include:

i) Design manuals, including system commissioning reports.

ii) Site safety analysis report for solid waste management facility.

iii) Operating manuals for all equipment and systems (refer to Annexure-II ).

iv) Chemical and radio-chemical assay procedures and manuals.

V) Waste handling and transport manual.

vi) Radiation emergency response plans.

vii) Work authorisation, isolation/protection procedures.

viii) Plant process flow sheets.

ix) Process and instrumentation diagrams.

x) Fire order.

xi) AERB safety manual on 'Radiation Protection for Nuclear Facilities' (AERB/ SM; 1996) and plant manual on 'Radiation Protection'.

xii) Any other document specified by AERB.

4.2.5 Quality Assurance (QA) Programme

4.2.5.1 A QA programme should be established and implemented to provide Bassurance on the quality of process inputs, on the characteristics of the products and ensure compliance with the prescribed standards.

4.2.5.2 The quality assurance programme should include:

i) condition monitoring of components and systems important to safety;

ii) process review and operator re-qualification;

iii) charaterization of waste, conditioned waste products and waste packages;

iv) identification of appropriate methods for periodic in-service inspection for critical portions of the piping and equipment; and

v) technical audit.

4.2.6 Maintenance

4.2.6.1 Corrective as well as preventive maintenance of waste management systems and equipment should be carried out in a manner to ensure that:

i) repairs and restoration of equipment and systems proceed as per aproved procedures and thereby minimise secondary waste generation,

ii) personnel exposures are minimised, and

iii) contamination is confined.

4.2.6.2 The maintenance programme should be established using information from design documents and instructions provided by manufacturers. The planning should consider the following:

i) availability of trained and qualified personnel;

ii) safety precautions and work environment (e.g. protections, isolations etc.);

iii) availability of adequate and appropriate spares and tools;

iv) performance verification tests after restoration; and

v) corrective and preventive maintenance.

4.2.7 Surveillance

4.2.7.1 The overall waste management operations strategy should include on-site and off-site monitoring system to detect any abnormal release from waste management plant and disposal facilities. Timely detection of failure of the barriers and release of radioactivity into the environment is essential to mitigate and limit the consequences.

4.2.7.2 The surveillance and monitoring programme should include:

i) monitoring of radioactivity in the environmental matrices such as ground water, soil and vegetation, food, etc., and

ii) monitoring of ingress of water in the disposal facilities like RCC trenches and vaults.

4.2.8 Records

4.2.8.1 A system should be developed for generation, retention and retrieval of records pertaining to waste receipt, storage, transfer, treatment, conditioning, packaging and disposal in a manner to provide evidence of regulatory compliance in an auditable form. The disposal records shall be maintained for posterity as specified.

# 5. CONTROL OF WASTE GENERATION

## 5.1 General

5.1.1 Nature and amount of waste generated in nuclear power plant depends on fuel clad integrity, leaks from active fluid handling system, housekeeping standards, etc. However, generation of radioactive waste, both in terms of volume and activity, should be minimised by adopting the following measures:

i) Design

a) Identification of sources.

b) Classification of waste streams.

c) Segregation of waste materials and streams.

d) Minimisation and collection of system leaks,

ii) Administrative Control

a) Compliance with operational limits and conditions.

b) Training of personnel.

c) Adherence to correct operating and maintenance procedures and implementing quality assurance/quality surveillance plans.

d) Good housekeeping.

iii) Performance Review

a) Review of operational data vis-a-vis design intent and specifications and identifying need for modification and implementation thereof.

5.1.2. In order to meet the contingencies arising from Anticipated Operational Occurrences (AOOs), spare storage and processing capacities should always be maintained. This can be achieved by keeping inventory of waste volumes low and by timely and regular processing. Likewise, performance monitoring for each system/equipment should be an on-going practice.

## 5.2 Sources of Radioactive Waste and Reduction Measures

The sources of radioactive waste generation in PHWRs are summarised in Appendix-A. The schematics indicating the sources and management for liquid waste are given in Annexures-III A and B and that for solid waste in Annexure-III C.

5.2.1 Gaseous Waste

5.2.1.1 Sources

Gaseous waste arise basically from:

i) contamination of ventilation system by tritium due to leakage of $D_2O$ vapours;

ii) contamination of ventilation system by fission product noble gases (FPNGs), radio-iodines and particulate activity due to presence of failed fuel; and

iii) activation of air (viz. Ar-41, due to presence of air between calandria and coolant channel annular space and in calandria vault in first generation of reactors).

5.2.1.2 Reduction Measures

The following measures should be used to keep the generation of gaseous waste to a minimum as far as practicable:

i) Ensuring system leak tightness and proper segregation of light and heavy water leaks.

ii) Improving recovery and recycling of tritiated heavy water.

iii) Confining the leakage and prevention of isotopic dilution.

iv) Detritiation of the reactor coolant and moderator system heavy water to keep the tritium inventory as low as possible.

iv) Operating the reactor in such a way as to minimise fuel failures.

v) Use Argon free gas in the annulus between calandria tube and coolant channel.

5.2.2 Liquid Waste

5.2.2.1 Sources

The liquid waste streams at PHWRs basically arise from:

i) Leakages from reactor systems.

ii) Process rejects from heavy water clean-up and upgradation.

iii) Spent resin de-deuteration and fluidisation.

iv) Spent fuel storage and inspection bay area leaks and rejects.

v) Decontamination of personnel, clothings, equipment and components and floors.

vi) Equipment and system draining, including bioassay laboratory drains.

vii) Secondary waste from waste treatment and conditioning.

viii) Oil leakages from oil supply unit (OSU) system and other pump motor bearing lubrication systems.

5.2.2.2 Reduction Measures

The following measures should be used to keep the generation of liquid waste to a minimum as far as practicable:

i) Operating the reactor in a manner so as to avoid fuel failures. In case of fuel failure, the failed fuel bundles should be removed as soon as possible.

ii) Reducing leakages from the primary coolant system and other related systems.

iii) Planning and performing maintenance work with due care and with particular emphasis on precautions to minimise the spread of contamination.

iv) Taking adequate precautions to minimise the contamination of equipment and tools so as to reduce the need for decontamination.

v) Ensuring proper contamination monitoring and usage of appropriate decontamination procedures and management of waste generated thereof.

vi) Reducing the generation of secondary waste by proper selection of waste treatment methods.

5.2.3 Solid Waste

5.2.3.1 Sources:

Solid radioactive waste basically arise from:

i) purification system (spent ion-exchange resins, cartridge filters);

ii) ventilation system (HEPA filters, activated charcoal filters);

iii) sludges from chemical treatment and evaporator system;

iv) contaminated non-reusable components/hardware, contaminated trash, potential active waste like cotton rags, tissue papers etc.; and

v) gaseous/liquid waste treatment system (secondary waste).

5.2.3.2 Reduction Measures

The following measures should be used to keep the generation of solid waste to a minimum as far as practicable:

i) Proper planning and performance of maintenance work.

ii) Careful movement of radioactive material.

iii) Optimised operation of:

(a) liquid and gaseous waste treatment systems, and

(b) PHT, moderator and spent fuel storage bay purification systems, etc.

iv) Provisions for effective contamination control and proper segregation practices at the source.

5.3 Classification and Segregation of Waste

5.3.1 Gaseous Waste

Gasesous wastes are categorised according to activity concentration as follows [ 7 ]:

| **Category** | **Activity Level (A) for Beta-Gamma Emitters $Bq/m^3$ ($Ci/m^3$)** |
|---|---|
| I | $A \leq 3.7 (A \leq 10^{-10})$ |
| II | $3.7 < A \leq 3.7x l0^4 (10^{-10} < A \leq 10^{-6})$ |
| III | $7x10^4 < A (10^{-6} < A)$ |

5.3.2 Liquid Waste

5.3.2.1 Liquid waste are categorised as per the radionuclide content/specific activity, type of radioactivity (like beta-gamma or tritium), ionic impurity levels, dissolved/suspended solid contents, organic impurities (like oil/grease), detergents and chemical content etc. Liquid wastes are also categorised as per the activity concentration as follows [7]:

| **Category** | **Activity Level (A) for Beta-Gamma Emitters Bq/m$^3$(Ci/m$^3$)** |
|---|---|
| I | $A \leq 3.7 \times 10^{4}$ $(A \leq 10^{-6})$ |
| II | $3.7 \times 10^{4} < A \leq 3.7 \times 10^{7}$ $(10^{-6} < A < 10^{-3})$ |
| III | $3.7 \times 10^{7} < A \leq 3.7 \times 10^{9}$ $(10^{-3} < A \leq 10^{-1})$ |
| IV | $3.7 \times 10^{9} < A < 3.7 \times 10^{14}$ $(10^{-1} < A \leq 10^{4})$ |
| V | $3.7 \times 10^{14} < A$ $(10^{4} < A)$ |

5.3.2.2 Segregation into Streams

The existing practice of segregation used for different categories of liquid waste streams in PHWRs based on their chemical and radio-chemical characteristics is as follows (see Annexure-III B):

| Stream | Sources of Generation |
|---|---|
| i) PAW - Potentially Active Waste | Showers, wash rooms, laundry. |
| ii) ANCW- Active Non-Chemical Waste | Spent fuel inspection bay, floor drains from active areas, laboratory drains, dedeuteration and clean-up plant area rejects. |
| iii) ACW - Active Chemical Waste | Decontamination of equipment and laboratory drains. |
| iv) TTW-I - Tritiated Waste | Reactor Building sump and Reactor Auxiliary Building sump (Tritiated Effluents with high beta-gamma activity). |
| v) TTW-II - Tritiated Waste | Rejects from $D_2O$ Upgrading plant and rejects from dedeuteration (tritium rich effluents with low gross beta and gamma activity). |
| vi) Active Organic Waste | Contaminated oils, greases and spent scintillation solutions. |

5.3.3 Solid Waste

5.3.3.1 To facilitate use of appropriate conditioning and disposal options, the solid waste are categorised according to the surface radiation dose and radionuclides inventory. The following are the different categories [7]:

| Category | Radiation Dose Rate (D) on the Surface of Waste Package mGy/h [R/h (approximately)] | Remarks |
|---|---|---|
| I | $D \leq 2$ [$D \leq 0.2$] | Beta -Gamma emitters. |
| II | $2 < D \leq 20.9$ [$0.2 < D \leq 2$] | Beta - Gamma emitters. |
| III | $20 < D$ [$2 < D$] | Beta - Gamma emitters. |
| IV | Alpha bearing waste | Alpha emitters dominant. Activity expressed in $Ci/m^3$ or $Bq/m^3$. Alpha-bearing waste are not normally encountered in NPPs. |

5.3.3.2 Suitable direct/indirect methods should be established to estimate radioactivity content and type of radionuclide present in the solid waste packages sent for disposal.

5.3.3.3 Solid waste are also categorised in terms of non-radioactive characteristics:

i) Combustible and non-combustible.

ii) Compactable and non-compactable.

iii) Special features e.g. items of significant commercial value and

iv) Chemical nature.

5.3.3.4 The segregation of solid waste should be carried out at the source itself based on the categorisation as per section 5.3.3.1 above and stored in designated receptacles located in the plant.

## 5.4 Monitoring of Waste

5.4.1 General

Plant processes generating waste should be monitored, using on-line monitors and/or by grab sampling analysis. This includes monitoring of physical and chemical parameters, radioactivity and radionuclide content. To ensure compliance with prescribed limits, effluent discharges (gaseous and liquid) shall be monitored at the appropriate locations at discharge points using properly established procedures and equipment. Procedures for sampling, analysis and calibration of measuring instruments should be properly established.

5.4.2 Objectives of Effluent Monitoring

The objectives of effluent monitoring are as follows:

i) to obtain information about source quantification and characteristics of the radioactive waste;

ii) to provide adequate information in order to demonstrate compliance with regulatory requirements;

iii) to assure proper operation of waste treatment system;

iv) to assure control over the effluent releases to the environment;

v) to assure on-site and off-site radiation protection; and

vi) to provide information for the action to be initiated in case of accidental high activity releases, so as to limit the consequences.

5.4.2.1 Gaseous Effluent Monitoring

5.4.2.1.1 Provisions to monitor ventilation exhaust air from different plant areas (like calandria vault, fuelling machine vault, reactor building, service building) and from main stack should include necessary sampling and monitoring system for release rate measurements of tritium, Ar-41, FPNG radionuclides, radio-iodines and particulate activity as and when required.

5.4.2.1.2 The online monitoring of activity release from the stack in respect of active inert gases, particulates and iodine activity should be available with recorder and alarm systems. There should be a standby system for sampling monitoring. A reliable power source for this system should be ensured. In case of tritium activity, a continuous sampling system should be available. The above arrangement should be housed in stack monitoring room.

5.4.2.1.3 Performance testing of HEPA filter banks/activated charcoal filters, should be periodically carried out as per procedures.

5.4.2.1.4 Incinerator system off-gases should be monitored for activity/radionuclide content before release into atmosphere.

5.4.2.2 Liquid Effluent Monitoring

i) provision should be made to obtain representative samples of liquid radioactive waste at every stage of the process.

ii) sample lines should be as short as possible and routed to a common sampling station for operator convenience and minimisation of operator exposure.

iii) sampling flow rate should be such that turbulent flow is maintained. Samples should be collected only after thorough flushing of the sample lines and flushing liquids should be recycled. Sample line as well as sample sink drain should be routed to appropriate collection tank or active waste collection sump.

iv) continuous sample collection at main-out-fall (MOF) after mixing of treated liquid waste with dilution water should be made to ensure proper monitoring of liquid waste discharges into the environment. Availability of sampling system round the clock should be ensured to meet desired periodicity of sampling. The sampling system should have adequate sample volume collection to meet this requirement. Provision to recycle the sample tank contents to main discharge channel/header should also be made. If the sample collection is done using a pump, necessary indication should be provided in the control room to ensure that sample pump trips do not go unnoticed.

v) approved radioactive assay procedures should be used for characterising the waste. The accuracy and the operability of on-line monitoring as well as laboratory instruments should be ensured through proper checks and calibration.

5.4.2.3 Solid Waste Monitoring and Surveillance

5.4.2.3.1 All solid waste packages shall be monitored for radiation field and tagged. As far as possible, standard packages with fixed geometry should be used to facilitate direct/indirect estimation of radioactivity content using established correlation factors.

5.4.2.3.2 RCC vaults/trenches shall be periodically monitored for water seepage.

5.4.2.3.3 Sampling and monitoring of water samples from boreholes provided around the near surface disposal facility should be carried out at the pre-defined frequency to check integrity of the engineered barriers.

## 5.5 Sources of Radioactive Waste in BWRs and Reduction Measures

Sources of radioactive waste in BWRs and measures to be taken for waste reduction are presented in Annexure-V.

# 6. WASTE TREATMENT

## 6.1 General

Liquid, solid and gaseous waste, containing fission and activation products, are generated during operation of NPP. Alpha emitters may be present at very low level. It is important to develop and adopt a safe, economically viable and efficient treatment, conditioning and disposal system to ensure compliance with the regulations. These systems are elaborated below (for schematics, refer to Annexure-III A, Annexure-III B and Annexure-III C ):

## 6.2 Liquid Waste

### 6.2.1 Segregation

Various types and categories of liquid waste are generated during nuclear power plant operation. The waste should be segregated at the source itself to achieve minimisation of secondary waste generation, discharges and operational costs. The segregation should be carried out as described in section 5.3.2.1.

### 6.2.2 Treatment

The selection of treatment method for liquid waste is primarily based on the following practices:

- Dilute and Disperse
- Delay and Decay
- Concentrate and Contain

Any one or more of the following methods may be used for treatment of liquid waste depending upon its radiochemical nature:

i) Dilute and Disperse

Filter, dilute and disperse, for waste containing low tritium and low gross beta activity (Category-I - PAW).

ii) Delay and Decay

Delay, filter, dilute and discharge, for short lived nuclides (Category I -PAW and Category II - ANCW)

iii) Concentrate and Contain

a) Filtration

b) Chemical treatment (Category II and III-ANCW and ACW)

c) Ion-exchange (Category II and III-ANCW)

d) Steam evaporation (Category III - ANCW and ACW)

e) Solar evaporation (Category II, III and tritiated waste - ANCW and TTW)

f) Reverse osmosis/ultra filtration (Category II & III - ANCW and ACW)

g) Incineration (for organic liquids and lube-oils).

6.3 Solid Waste

6.3.1 Segregation

Solid waste should be segregated as categorised in section 5.3.3, and stored in designated receptacles located in the plant.

6.3.2 Conditioning

6.3.2.1 Any one or combination of the following treatment and conditioning processes may be used:

i) Compaction (for category I and II compactable waste).

ii) Incineration (for category I combustible waste).

iii) Cementation (for molecular sieves, filter elements, incinerator ashes and wet waste like sludge, etc. of category I, II and III waste).

iv) Encapsulation in containers.

a) Filling, compaction and sealing in metallic drums/containers (for all categories and types of waste)

b) Encapsulation and sealing in high integrity containers (HIC) (for category-III waste)

v) Immobilisation of spent resins.

## 6.4 Gaseous Waste

The type of treatment to be provided for different gaseous streams is decided at the design stage itself, taking into consideration any anticipated activitiy. For gaseous waste, on-line decontamination and cleaning provisions are available through gas cleaning and decontamination systems along with the reactor building ventilation system itself. During normal reactor operation, the main contaminants are:

i) fission product noble gases (Isotopes of Xe and Kr);

ii) activation products, gases (e.g. Ar-41 and Tritium);

iii) particulate activity; and

iv) radio-iodines.

### 6.4.1 Treatment

The following treatment methods are employed for different contaminants:

| SL.No. | Gaseous Waste | Management Method |
|---|---|---|
| i) | Fission product noble gases and Ar-41 | Delay, filtration, dilution and discharge |
| ii) | Tritiated water vapors | Desiccant beds and molecular sieves |
| iii) | Iodines | Absorption on activated charcoal beds |
| iv) | Particulate activity | Filtration through pre-filters and high efficiency particulate air filters (HEPA) |
| v) | Waste incinerator of gasses | Gas scrubbers or high temperature gas filters, cyclones, bag filters and HEPA filters |

# 7. WASTE STORAGE AND DISPOSAL FACILITIES

## 7.1 General

7.1.1 Sufficient storage capacity should be provided for storage of liquid and solid waste arising during normal operation as well as for anticipated operational occurrences. Some effluent streams after filtration and monitoring may be discharged (within specified limits as given in technical specifications) directly into the environment.

7.1.2 All waste shall be monitored prior to storage or disposal.

7.1.3 Storage areas should be monitored routinely for radiation and contamination. Access to storage areas should be restricted to authorised persons only.

7.1.4 Proper scheduling of treatment/processing operations should be carried out in order to minimise holdup of waste volumes to make available adequate storage capacity for exigencies and to minimise personnel exposures. However, storage also is a method for achieving reduction in activity by decay.

7.1.5 Waste should be stored in such a way as to prevent spillage. Spillages, if any, should be retrieved.

7.1.6 Containers/tanks/sumps should be periodically monitored for radiation level and surface contamination to assess the need for minimising accumulation of sludges and buildup of radiation field.

7.1.7 The inventory of waste receipt and discharge should be recorded in accordance with AERB requirements.

7.1.8 All effluent discharges and holdup should meet the intent of ALARA principle.

## 7.2 Storage and Disposal Systems

7.2.1 Liquid Waste

7.2.1.1 All liquid waste streams should be segregated at the source based on chemical composition and radio-chemical nature of the waste for further processing.

7.2.1.2 Volume and activity of waste under storage shall not exceed the technical specifications limits.

7.2.1.3 Liquid waste shall be monitored on batch basis through appropriate sampling and analysis. The discharges should be controlled within the prescribed limits. The chemical contents in effluent discharges should meet the requirements of Environmental Protection Act and other statutory bodies.

7.2.1.4 Records should be maintained for relevant parameters like waste volume discharged, discharge rate, dilution water flow, pH, gross beta activity and Tritium and radionuclides content.

7.2.1.5 Liquid waste streams should be discharged only after filtration and adequate dilution.

7.2.1.6 Availability of devices for flow control and activity monitoring should be ensured.

7.2.1.7 Provision for collecting continuous samples at the MOF, after dilution, should be made to verify that the liquid waste discharges are kept within the prescribed limits.

7.2.1.8 No waste shall leave the plant boundary unmonitored.

7.2.1.9 All discharges beyond plant boundary should be through a single point and authorised route.

7.2.1.10 Small quantities of contaminated oils with low contamination levels are generated during operation of NPPs. These oils may be burnt and gases released into the atmosphere in a controlled manner. Alternatively, these oils could be soaked in an absorbing media and disposed off in earthern barriers or appropriate engineered barriers. These activities should be carried out as per approved procedures.

7.2.2 Solid Waste

7.2.2.1 All solid waste should be segregated at the source based on physical nature, surface dose rate and processing/disposal methodologies. The disposal of low and intermediate level radioactive solid waste in near surface disposal facility (NSDF) is relatively simple and economical. To meet the safety objectives, a multi-barrier approach should be adopted.

7.2.2.1.1 The barriers which are employed to retard and slow down the migration of radionuclides into the environment are:

i) waste forms and waste packages,

ii) engineered barriers such as concrete structures and backfill materials: and

iii) geo-environment of the site.

7.2.2.1.2 Solid waste are disposed off in the following types of near surface disposal facilities:

i) earth trenches (potentially active waste);

ii) R.C.C. Trenches and vaults (category I, II. III and waste having surface dose rate upto 50 R/h); and

iii) Tile holes/HIC (category III waste having surface dose rate more than 50 R/h).

7.2.2.2 The following methods should be adopted for storage and disposal of solid waste:

i) Collection receptacles (standard M.S. drums-shielded or unshielded) should be located at designated places in the plant. Their capacity should be sufficient to accommodate the expected waste, pending its collection.

ii) Number of receptacles at each collection point should be planned according to the types and volume of waste generation at that point. All receptacles should be properly marked for intended use.

iii) All waste containers like barrels, drums, resin hoppers, etc. should be properly sealed and tagged indicating the radiation level, nature of waste, etc. before shipment.

iv) On-site storage provisions should be made for interim storage of these containers pending treatment and disposal.

v) Suitable material handling systems like fork-lift, trucks, low bed tractor trailer, gantry cranes etc., should be planned for shipment and disposal of untreated/treated/conditioned solid waste.

vi) Approved transport, treatment, conditioning and disposal procedures should be used.

vii) Suitable disposal methods shall be planned.

viii) The waste should be disposed only in the designated disposal facility.

ix) The methodology of interim closure of RCC trenches and tile holes should be developed by the operating organisation and approved by AERB.

x) The final closure plans for the repository shall be prepared well in advance by the operating organisation and approved by AERB.

# 8. WASTE TRANSFER AND TRANSPORT

## 8.1 General

8.1.1 The transfer and transportation system for liquid and solid waste involves specifying procedures and control measures, including documentation of the waste. The transfer and transportation of liquid and solid waste generated in NPPs require appropriate systems for safe handling at consignor and consignee's premises. The procedures and control measures, including documentation, need to be developed. The transfer and transport system may be required within and outside the site premises.

## 8.2 Transfer and Transport of Liquid Waste

8.2.1 Transfer

The following considerations need to be given in the transfer of liquid waste through pipelines:

i) Overground pipelines passing beyond access controlled area of the facility should be protected by fencing along the route.

ii) Compatiblity of the material of the pipeline with the waste being transferred and with the environment should be ensured.

iii) Leakage of the pipelines should be monitored periodically at inspection chambers leak collection sumps along the route.

iv) Pipelines should be tested periodically for their integrity.

v) Appropriate mechanism to interpret system data and for initiation of necessary corrective action should be adopted.

vi) Pipelines within and beyond plant boundary should be laid as per approved AERB guidelines.

### 8.2.2 Transport

8.2.2.1 The following points should be ensured for liquid waste transport by tankers:

i) The transporation of liquid waste by tankers should be as per the approved transport procedures and any deviations must have prior approval of the competent authority.

ii) The tanker should be shielded adequately.

iii) The tanker should be filled to a safe level to prevent spillage due to splashing caused by bad road conditions.

iv) The crew of the tanker should be informed about the action plans to be taken in case of contingencies, such as road accidents, spillages, vehicle breakdown, etc.

v) The material used in construction of the tanker should be compatible with the characteristics of the liquids to be transported.

8.2.2.2 In case of transporting liquid waste in closed containers, the following considerations should be ensured:

i) The closed containers must have radiation symbols indicating radiation levels. No container can have activity more than the prescribed limits.

ii) The vehicle carrying containers must have radiation symbols on the sides.

iii) Appropriate procedures/provisions including permit system must be made so as to avoid contamination at the point of loading/unloading.

iv) Closed containers carrying liquid waste should be placed in secondary containment.

v) Crew of the vehicle carrying the containers should be informed about the action plans to be taken in case of contingencies.

vi) The material used in construction of the container should be compatible with the characteristics of the liquids to be transported.

## 8.3 Transport of Solid Waste

8.3.1 Off-Site

The off-site transport of solid radioactive waste shall be as per the approved procedures meeting the requirements of the AERB Safety Code 'Tranpsort of Radioactive Materials' (AERB/SC/TR-1).

8.3.2 On-Site

8.3.2.1 In general, the packaging and transport requirements for on-site transport can be less stringent than those for off-site transport. Precautions to be taken while transporting solid waste on-site depend mainly on the activity, the packaging and surface contamination. Adequate packaging, shielding and supervision shall be provided to keep the exposure of site personnel to a minimum in accordance with the ALARA principle and to minimise the potential of the release of radioactive material in the event of a transport accident.

8.3.2.2 Prior to the despatch of package or the departure of vehicle carrying unpackaged material, the consignor should ensure that the radiation levels and surface contamination are within the limits prescribed by AERB.

8.3.2.3 Closed containers having potential for pressurisation, due to specific characteristics of the liquid waste, should be provided with safe pressure relieving provisions without causing any loss of integrity of the containment system.

# 9. EFFLUENT RELEASE CRITERIA AND ENVIRONMENTAL MONITORING

## 9.1 Effluent Release Criteria

### 9.1.1 General

The radioactive effluent releases into the environment, both aquatic and atmospheric, cause exposure to the members of the public through different pathways like external radiation, inhalation and ingestion of radioactive contaminants. Therefore, it is necessary to identify the exposure pathways and also the most exposed individuals (critical group) and develop systems (mathematical models, etc.) to estimate the dose commitment. It is therefore imperative to establish the following as a prerequisite to the environmental releases:

i) The baseline data on the environmental radioactivity at the site prior to the commencement of the operation of nuclear power plant.

ii) Chemical and radiochemical characteristics of the waste to be released.

iii) Quantities of the radioactivity estimated to be discharged during normal operations and also during off normal situations.

iv) Dispersion factors at locations of interest.

v) The bio-accumulation factors in the food chain.

vi) Consumption rates for various foodstuffs and dietary habits of the members of public at locations of interest.

vii) Dose conversion factors per unit activity intake, specific to the site.

### 9.1.2 Dose Apportionment

The exposure pathways and the nuclides that contribute to the total effective dose to the representative (critical) member of the public should be identified to ensure that the total dose received by any member of the (critical) group from all the exposure pathways and radionuclides does not exceed the prescribed effective dose limits. For further guidance refer to AERB Safety Guide AERB/ SG/O-5[10].

9.1.3 Derived Limits

9.1.3.1 Before the commencement of operation of NPP, the plant management should ensure the availability of approved dose apportionment and derived limits for different identified and authorised release routes. The derived limits (DLs) are based on the apportioned dose for different routes of discharge.

9.1.3.2 The plant management should ensure the adequacy of the waste management systems to meet requirements of the approved dose apportionment and derived limits of release through authorised routes.

9.1.4 Reference Levels

The plant management should establish reference levels reasonably lower than the DLs for assessing the result of monitoring and for prevention of exceeding authorised limits. There may be multi-tier reference levels. The action plans may be commensurate to each of these reference levels and appropriate action plans should be evolved and implemented, as necessary.

## 9.2 Monitoring and Control

All effluents shall be discharged only after monitoring. The activity of radionuclides discharged into the environment shall be assessed by means of continuous measurement or by sampling intermittently, as deemed appropriate. Provisions for prompt detection of a significant increase above normal rates of radioactive discharges and for identification and assay of the important radionuclides involved shall be provided for both gaseous and liquid effluents. If it is suspected that prescribed discharge limit has been exceeded, plant management shall:

i) Take actions to control the releases.

ii) Estimate the amount of radioactivity released.

iii) Initiate appropriate mitigating actions.

iv) Investigate the root cause and take remedial actions.

v) Report to AERB in accordance with prescribed procedures.

## 9.3 Environmental Monitoring

An environmental monitoring programme, including a pre-operational survey, to establish baseline data shall be implemented in accordance with the requirements of AERB. This programme is carried out to:

i) determine the radiological impact of effluent discharges;

ii) demonstrate compliance with the prescribed limits; and

iii) make available meteorological data on wind velocity profile at different heights, wind direction, rainfall etc., to main control room to facilitate suitable course of action in plant emergencies.

9.3.1 Pre-operational Programme

9.3.1.1 The purpose of this programme shall be to:

i) provide measurements of background radiation and radioactivity levels and their variations in environmental matrices in the area surrounding the plant and record data for future comparison; and

ii) establish procedures, identify equipment and techniques and provide monitoring experience to the personnel.

9.3.1.2 To ensure a sufficient data base which includes seasonal variations, the programme should be established 2-3 years before the nuclear power plant is put into operation. It should include the routine collection of various samples (e.g. vegetation, sediment, fish, milk, air, water and other environmental media). The samples should be collected from fixed and identified locations, both on-site and off-site and analysed for the types of radioactivity which may be released from the plant. These results are used in conjunction with a habitat survey (including dietary trends) to facilitate in assessing the environmental impact of nuclear power plant.

9.3.2 Operational Programme

9.3.2.1 An environmental monitoring programme during the operational phase of NPP shall be implemented as an extension of the pre-operational programme. The sample material and the location identified during this programme should be same as that in the pre-operational stage. The sample collection may, however, have a different frequency (e.g. milk may be sampled more frequently and sediment less frequently). The programme should be reviewed in the light of experience and modified, if necessary.

9.3.2.2 The programme should be such as to provide information for:

i) assessing radiation exposure of the public and in particular the members of critical group;

Ii) correlating environmental monitoring results with effluent monitoring data;

iii) checking the validity of environmental models used in establishing authorised limits; and

iv) assessing trends of radionuclide concentrations in the environment.

9.3.3 Sampling, Analysis and Evaluation

9.3.3.1 Samples obtained from the surrounding environment of nuclear power plant should be representative. They should be collected and handled in such a way as to avoid contamination. In the selection of representative sampling locations, meteorological and hydrological factors, land and water usage and population distribution should be taken into account.

9.3.3.2 Samples should be analysed to determine the radionuclides, released from nuclear power plant into the environment, that are significant for radiation exposure of the public. In order to do this, it is necessary to determine the contribution of other sources of radiation, including natural background as determined in the pre-operational programme and contributions from other nuclear facilities or from global fallout.

# 10. RECORDS, DOCUMENTATION AND REVIEW

## 10.1 General

10.1.1 A proper system of record keeping and its maintenance shall be established by the plant management/operating organisation. These records should be in line with AERB requirements and should contain information concerning the discharge of effluents, on-site storage and off-site dispatch of treated and untreated waste, monitoring and assessment of radiological impacts and the operation and maintenance of components and systems. Records of waste management system can be broadly categorised into two namely, permanent and non-permanent.

10.1.2 Permanent records comprise the following:

i) disposal and transfer records;

ii) surveillance records;

iii) storage records; and

iv) system modification records.

10.1.3 Non-permanent records comprise the following:

i) regulatory inspection and testing records;

ii) WMP operational records (viz. logbook, SRUORs and other special reports etc.); and

iii) receipts, handling and interim storage records.

## 10.2 Information to be Contained in Different Types of Records

Only prescribed forms should be used for recording the data pertaining to different waste management operations. Some of the specific requirements of data recording are given in the following subsections.

10.2.1 Disposal Records

Disposal records of radioactive waste should contain:

i) Physical form.

ii) Chemical characteristics.

iii) Method of conditioning.

iv) Volume (m3) disposed off on a particular day.

v) Radionuclides present.

vi) Specific activity concentration.

vii) Total activity disposed (MBq) on a particular day.

viii) Mode of disposal.

ix) Location of disposal sites.

x) Data pertaining to environmental surveillance at the disposal sites.

xi) Remarks, if any.

Typical record keeping formats for waste management system, waste disposal and waste reporting are given in Annexures IV-A, B, C and D.

10.2.2 Surveillance Records

Surveillance records should contain information on following:

i) maintenance of system and components;

ii) on-site and off-site leakage of radioactive effluents;

iii) monitoring of systems which are required for minimising leakages;

iv) process system chemistry to inhibit corrosion and scaling;

v) contamination monitoring;

vi) radiation surveillance on packed, stored and transferred waste; and

vii) environmental and meteorological surveillance.

10.2.3 Storage Records

10.2.3.1 Solid and Liquid Waste

The storage record for solid and liquid waste should contain information as mentioned under sections 10.2.1 and 10.2.2 along with the following:

i) Location and description of container and storage area.

ii) Data on volumes and activity of stored waste.

iii) Surveillance records of storage site, such as radiological conditions, monitoring of physical conditions of stored waste packages, etc.

10.2.4 Records for Inspection and Regulatory Requirements

To confirm the compliance of regulatory requirement and the enforcement of Safe Disposal of Radioactive Waste Rules, 1987, the organisation should maintain monthly records in Form III for the disposal or transfer of radioactive waste and these should be available to AERB staff for inspection. Periodical returns, as stipulated in the authorisation for safe disposal or transfer of waste, should be submitted in Form IV to AERB. The existing proforma for Form III and Form IV are given in Annexure IV- C and D respectively.

10.2.5 WMP Operational Records

The following records should be maintained:

i) Data logs.

ii) Chronological logs.

iii) Descriptive log.

iv) Recorder charts.

v) Maintenance history cards.

vi) Area operators log.

vii) Work permits.

viii) Discharge permits.

10.2.6 Waste Receipts Records

The minimum requirements for waste receipt records for liquid and solid waste are given in the following subsections:

10.2.6.1 Liquid waste receipt information details are :

i) Source of generation.

ii) Date of receipt.

iii) Chemical characteristics.

iv) Total volume ($m^3$).

v) Number of drums containers or tanks and their identification numbers.

vi) Radionuclides present.

vii) External radiation levels on the drums, containers or tanks.

viii) Average concentration of waste in the container.

ix) Total activity (MBq) of waste in the container.

x) Category of waste.

10.2.6.2 Solid waste receipt information details are:

i) Source of generation,

ii) Date of receipt,

iii) Physical forms.

iv) Chemical characteristics (specific mention of flammable/ pyrophoric or alpha waste).

v) Type of packaging.

vi) Mode of receipts.

vii) Radionuclides present.

viii) Total volume (m3).

ix) Total activity content.

x) External radiation levels on the package.

xi) Category of waste.

10.2.7 Waste Handling Records

The information requirements for maintaining records of handling gaseous, liquid and solid waste are given in the following subsections.

10.2.7.1 Gaseous waste information required are:

i) Radio-chemical characteristics.

ii) Volume (m3 ) per day/month.

iii) Total activity (MBq) per day/month.

iv) Data for operating temperature and flow rate.

v) Efficiency and pressure drop across the filter.

vi) Date and frequency of testing of filter.

vii) Date of removal and replacement of filter element and absorption media.

viii) Data of off-gas monitoring.

10.2.7.2 The solid and liquid handling records will contain all the points mentioned in section 10.2.1 and the 'methods of conditioning'.

## 10.3 Retention of Records

10.3.1 The records for inspection and that of regulatory requirement should be preserved by the installation as required by AERB. However, solid waste disposal records should be kept for an extended period of time and sent to the archives.

10.3.2 In addition to all the records as mentioned under sections 10.1.2 and 10.1.3, the operating organisation/plant management should make available the following documents relevant to waste management operations in good and updated conditions:

i) Technical specifications.

ii) Authorisation for the disposal or transfer of radioactive waste.

iii) Operating manuals.

iv) Operating flow sheets.

v) Emergency preparedness plans.

vi) Control schematics.

vii) Commissioning reports.

viii) Safety analysis reports.

ix) Design manuals.

x) UORs and technical specifications violations.

xi) Personnel exposure data.

xii) Surveillance records.

## APPENDIX-A

### SOURCES OF RADIOACTIVE WASTE GENERATION IN PHWRs (Refer Section 5.2)

| SI. No. | System | Solid Waste | Liquid Waste |
|---|---|---|---|
| 1. | PHT (purification system) -nents | Spent IX resins, spent filters, contaminated compo | low I.P.* $D_2O$ from leakages |
| 2. | Moderator (purification system) | Spent IX resins | Leakages of $D_2O$ going to RB sump |
| 3. | Spent Fuel Storage and Inspection Bay clean up system | Spent IX resins, spent filters | Active non-chemical liquids with high gross beta activity |
| 4. | PHT circulating pump gland supply | Spent filters | Leakage of $D_2O$ and subsequent downgrading |
| 5. | Downgraded $D_2O$ and upgrading rejects | Spent IX resins, sludges | Low I.P. rejects from upgrading plants |
| 6. | $D_2O$ vapour recovery dryers | Exhausted molecular sieve | Low I.P condensate as reject |
| 7. | Chemical laboratory | Assorted paper waste, glassware and mops effluent | Category I and II active chemical liquid |
| 8. | Laundry | Rejected clothings | Detergent waste |
| 9. | Decontamination (personnel and equipment) | Cottons | Category I, II and occasionally Category III |

## APPENDIX-A

**SOURCES OF RADIOACTIVE WASTE GENERATION IN PHWRs**
**(Refer Section 5.2) (contd.)**

| SI. No. | System | Solid Waste | Liquid Waste |
|---|---|---|---|
| 10. | Maintenance activity | Assorted waste, discarded tools and equipment | Category I |
| 11. | Spillage of H2O in RB/RAB | Mops, cottons | Category II |
| 12. | Ventilation and exhaust | HEPA filters, Iodine filters (Activated charcoal bed) | Category II condensates |
| 13. | a) Spent resin de-deuteration reject | - | Low IP rejects containing liquid with suspended resin particle with activity |
| | b) Resin fluidisation operations | | |
| 14. | Various systems activated/discarded system hardware | Contaminated/ | |
| 15. | Reactor Auxilliary system | Spent resin/filters | |

* IP. - Isotopic Purity (typically < 0.3 % w/w)
R.B. - Reactor Building
RAB - Reactor Auxilliary Building

# APPENDIX-B

## WASTE FROM OFF-NORMAL CONDITIONS/ANTICIPATED OPERATIONAL OCCURRENCES, LOCA AND DECOMMISSIONING OF NPPs
**(Refer Section 1.3.2)**

### B. 1 Off-Normal Conditions/Anticipated Operational Occurrences (AOOs)

Large volumes of liquid and solid waste may arise from NPP during off-normal conditions AOOs. WMP should have reasonable built-in capacity for handling such waste. Substantial quantities of liquid and solid waste are also generated in non-routine operations of the NPP, such as in coolant channel replacement (CCR), in chemical decontamination, etc. The management of such wastes will have to be done on a campaign basis in a planned manner. Off-normal conditions/AOOs resulting in large holdup of light water contaminated with radioactivity and waste generated in special campaigns are described in the following sections.

B.1.1 Waste Generated on Account of Leakage of Heavy Water into Process Water due to Heat Exchanger Tube Failure

Active Process Water (APW) system is a closed loop system and supplies cooling water to heavy water heat exchangers in the reactor building, shield cooling heat exchangers, spent fuel storage bay heat exchangers and emergency core cooling heat exchangers, etc. The holdup capacity of the system is of the order of 500 tonnes of light water for 220 MWe PHWRs reactor system. In the event of any heat exchanger tube failure, active heavy water would leak into the process water. In case of sudden large leaks, provision should be made to drain this water to a separately provided buffer tank (process water storage tank). Depending on isotopic purity, the water may be sent to the heavy water upgrading plant or to WMP as trititated waste. Typically, leakage of one tonne of moderator heavy water of specific tritium activity of 5 Ci/litre would mean disposal of 5000 Ci of waste with a D2O isotopic purity of about 0.2 % and tritium specific activity of 10 micro Ci/ml. Such a large quantity of tritiated waste needs to be managed in a planned manner. Generally the tritiated waste is disposed off after dilution with condenser cooling water (CCW) and subsequent dispersion in the water body in a phased manner.

B.1.2 Waste Generated on Account of Contamination of Secondary System due to Steam Generator Tube Leaks

Steam Generator (SG) tube leaks could result in thecontamination of the secondary system. Waste arising because of such occurrences should be led to the condenser hot-well/buffer tank. Inter-transfer of contaminated secondary system water to uncontrolled areas should be avoided. Management of this waste stream should be done on a campaign basis.

B.1.3 Waste Generated on Account of Leakage of Moderator Heavy Water into Calandria Vault Water

The possibility of incidents like double-ended rupture of calandria tube should be avoided by adopting improved design and in-service inspection (ISI). However, if such a rupture occurs, provision should be made for holding large volumes of waste arising from such incidents. Depending upon the activity level, a suitable action plan to manage such waste should be worked out.

B.1.4 Large Contamination in Spent Fuel Storage Bay (SFSB)

The SFSB water is kept clean by providing a separate purification system with filters and ion-exchangers to remove the fission products, if any. In case of large contamination of bay water due to fuel failure, additional solid waste in the form of spent filter cartridges and ion-exchanger resin will be generated. These additional quantities of solid waste will need to be accommodated in the existing waste conditioning storage and disposal system. WMP should be capable of catering to such situations.

**B.2 Coolant Channel Replacement (CCR)**

B.2.1 The PHWRs have coolant channels (pressure tubes) running through the reactor core. The coolant channels which hold the fuel bundles, undergo the ageing process due to neutron/Hydrogen embrittlement, creep/growth, etc., which may necessitate their replacement for continuing safe operation of the reactor.

B.2.2. Some of the earlier PHWRs are having nickel-free zircalloy-2 coolant tubes which may be required to be replaced after 8-10 full power years of reactor operation. The recent reactors having Zirc-Niobium tubes, which are reported to have better creep/growth properties, may need to be replaced at least once in the reactor life span.

B.2.3. Large quantities of solid radioactive waste having significant contamination will be generated during coolant channel replacement operations. The radionuclides present in significant quantities in the coolant channels and associated hardware are mostly activation products in non-leachable form, immobilised in the metallic matrices. Alpha activity is not expected to be associated with these wastes. Other long-lived beta emitters, like C-14, may be present as deposits in the form of complex chemical compound on outer surface of coolant tube and on the inner surface of calandria tubes as an activation product.

B.2.4 The components coming out from the core of the reactor may show a very high radiation field which may vary with the given cooling period. Waste quantities will also be large, to the tune of 200 Te for 220 MWe PHWRs. Its management will require careful planning and execution.

B.2.5 A waste management scheme for this waste shall include:

i) Preparation of project/safety analysis report for CCR and its approval by AERB.

ii) Complete radioassay of all the waste components to be conditioned and disposed off.

iii) Pre-conditioning of certain waste items at reactor site.

iv) Transportation of shielding flask and their handling at reactor site and waste management facility site.

v) Decontamination procedures for transport flasks and other equipment.

vi) Treatment/conditioning methods at waste management facility site.

vii) Secondary waste generation control and management.

viii) Storage facilities.

ix) Disposal at waste management facility site.

x) In-situ cement grouting facility.

xi) Pre-closure of disposal facilities.

xii) Operating procedures and checklist.

xiii) Qualification of men and machinery, equipment, tools and tackles required for the campaign.

xiv) Radiation protection plan and man-rem estimates.

xv) Quality surveillance plan.

xvi) Industrial safety plan,

xvii) Exigency plans.

B.2.6 Typical data on radiation fields after 8-10 full power years (FPYs) of reactor opeation, the radionuclides of concern and their specific activity and quantities of waste arising from 220 MWe PHWR en-mass coolant channel replacement operations is given in Annexure-VI.

Special Authorisation using Form-IA (see Annexure-IV E) shall be obtained from AERB before starting the above mentioned operations.

B.2.7 The waste management for operation of en-mass coolant channel replacement has high potential for industrial safety hazard, especially while handling heavy equipment and lead shielded flasks, tube cutting systems and operations of heavy cranes, etc. Therefore all measures and precautions shall be taken to prevent accidents [8].

B.2.8 Approved format for waste transfer/transport and disposal, post-disposal operations, radiation surveillance and radiological condition monitoring formats shall be used to record the data.

## B.3 Chemical Decontamination of Reactor Systems

B.3.1 Progressive deposit of activation and corrosion products on the oxide (magnetite) layer on the inner surface of the primary heat transport (PHT) system takes place during the course of operation of NPP. This results in high background radiation field. To reduce the background field, dilute chemical decontamination (DCD) may be used, wherever necessary. It involves dissolution of the oxide layer with dilute organic acids and removing the cationic and anionic activity using the ion exchange bed. The spent resin from these operations will require treatment and disposal.

B.3.2 For PHWRs, CED (Citric acid-EDTA and ascorbic acid) process may be used for PHT in-situ decontamination and removal of activation corrosion products, such as: Co-60, Fe-59, Mn-54 and fission products (namely, Ce-141/144, La-140, Ba-140, Zr-95, Na-95, Ru-106/103m, Sb-125,etc).

B.3.3 In case of BWRs. due to the different material of construction and water chemistry and chemical composition of oxide deposits, AP-CED process (Alkaline Permanganate, Citric Acid-EDTA-ascorbic acid) may be used for in-situ decontamination. The spent resin from this process will have mainly Co-60 and Cr-51 activity.

B.3.4 A typical reactor system decontamination may generate about 2400-5000 litres of spent resin in 6-8 cabon steel columns, having upto a few hundreds of curies. The conditioning and disposal of this spent resin should be carried out in the normal course with the following considerations:

i) approved procedures for handling, transport, conditioning and disposal,

ii) equipment, particularly shielding flask, qualified for the amount of activity and radiation field on the spent resin,

iii) material handling equipment like truck, cranes and forklift tested for adequate capacity and safe operation, and

iv) special Authorisation in Form-IA (refer Annexure-IV E) from AERB.

**B.4 Waste Generated on Account of LOCA**

B.4.1 The suppression pool is normally isolated from the areas having potential sources of heavy water leakages by vapour barriers. Significant contamination of the pool (typically about 2000 tonnes of light water for 220 MWe PHWRs) is expected during LOCA.

B.4.2 The disposal and/or replacement of this water would be a slow process and will be done in a planned manner over an extended period of time, depending upon its specific activity. Handling of this waste will be done on a campaign basis.

B.4.3 In case of a large LOCA resulting in extensive fuel damage and consequent release of an enormous quantity of fission product activity leading to closure of the facility, a detailed evaluation of waste generation, arrangements for its treatment, conditioning and disposal will be required. This may require the construction of a separate waste management facility. Such occurrences are outside the scope of this safety guide.

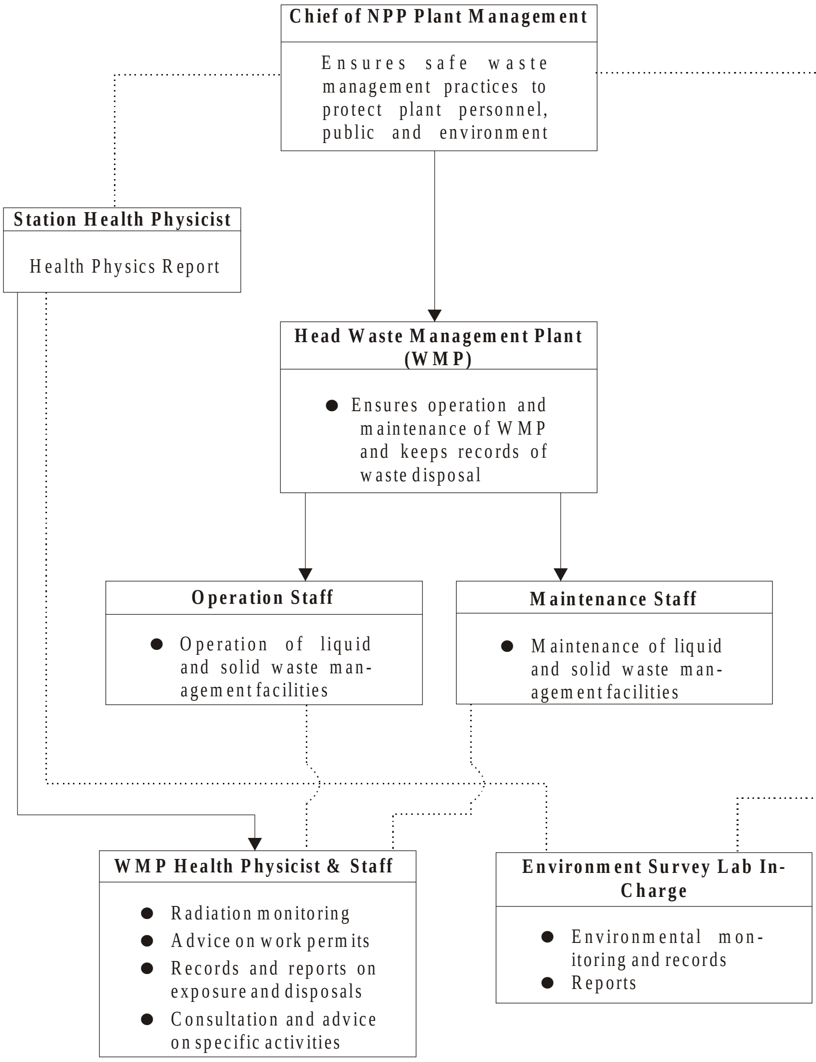
**B.5 Waste Arising from Decommissioning of NPP**

B.5.1 Waste generation during decommissioning and guidance for its management have been dealt in the AERB safety manual on 'Decommissioning of Nuclear Facilities'. As the decision for decommissioning of NPP and selection of time period for the same depend on several factors, the processing capacity for such decommissioning waste is generally not provided in the initial design of WMP. However, since the near surface waste disposal facility is located within the exclusion zone of NPP, adequate area needs to be provided taking into account the site burden for operational waste as well as waste from decommissioning.

B.5.2 A decommissioning plan, which among other things, should include planning and engineering for decontamination and dismantling, treatment, conditioning, transportation and disposal of waste, needs to be prepared by the operating organisation and submitted to AERB for approval, prior to decommissioning. The site safety analysis report on solid waste management facility for decommissioned solid waste needs to be prepared and submitted to AERB for review and approval.

# ANNEXURE- 1

## TYPICAL FUNCTIONAL ORGANISATIONAL CHART FOR WASTE MANAGEMENT PLANT AT NPP (Refer Section 3.2)




**Foot notes:**

1) Operation and maintenance staff shall be assigned from plant management as necessary
2) Health Physics staff may be assigned from station Health Physics group.
3) Analytical support from station Health Physics and Chemical Laboratory to be provided
4) Flow of command Interaction

# ANNEXURE-II

## OPERATING PROCEDURES
**(Refer Section 4.2.4)**

II.1 This Annexure lists a sample list of procedures which should be developed for the management of radioactive effluents/waste during NPP operation.

II.2 The systems/sub-systems (related to WMP) for which operating manuals/ procedures are to be developed include:

i) Reactor Building/Service Building/WMP ventilation systems.

ii) $D_2O$ Vapour Recovery System.

iii) Iodine removal system, particulate removal/filtration.

iv) Stack monitoring system_handling of tritium, noble gases, particulates and I-131.

v) Environmental monitoring.

vi) Waste packaging, handling and storage.

vii) Chemical control.

viii) Handling of abnormal releases of radioactive effluents.

ix) Filter performance monitoring and replacement programme– ventilation systems.

x) Packaging and transport of waste on-site and off-site.

xi) Operation of waste treatment systems.

xii) Operation of ventilation systems.

xiii) Actions to be taken under conditions of spills, uncontrolled releases, etc..

xiv) Methods for calculating dose to public from plant operation.

xv) Leakge monitoring into the ground.

xvi) Liquid effluent segregation system.

xvii) Laundry operations.

xviii) Decontamination operations.

xix) Waste discharge system.

xx) Ion-exchange system.

xxi) Resin transfer/fixation system.

xxii) Desludging operations.

xxiii) Filter replacement.

xxiv) Waste receipts.

xxv) Waste sampling.

xxvi) Waste transfer/transport operations.

xxvii) Compaction and incineration system.

xxviii) Procedures for all major equipment operation.

xxix) Plan for contigency handling.

xxx) Testing of HEPA filters.

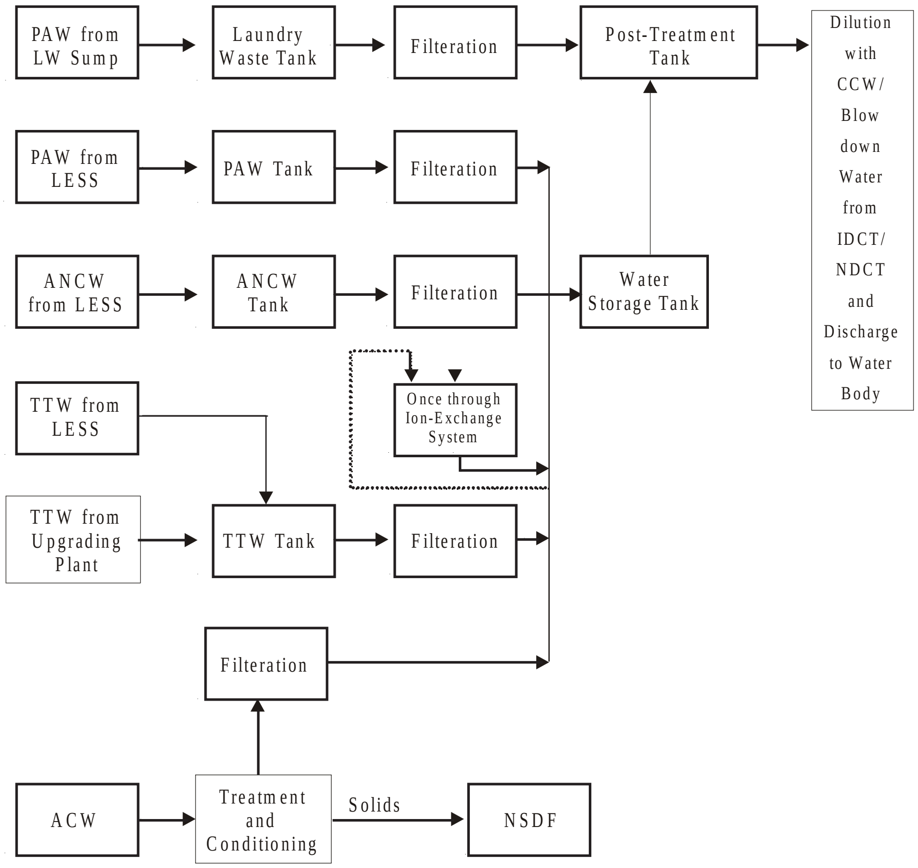
xxxi) Filter replacement and disposal.

xxxii) Solid waste management system.

xxxiii) Solid waste disposal, facility closure and sealing.

## ANNEXURE-IIIA

### PROCESS SCHEMATIC FOR PHWR LIQUID WASTE MANAGEMENT
### (Refer Sections 5.2.2 and 6.2)

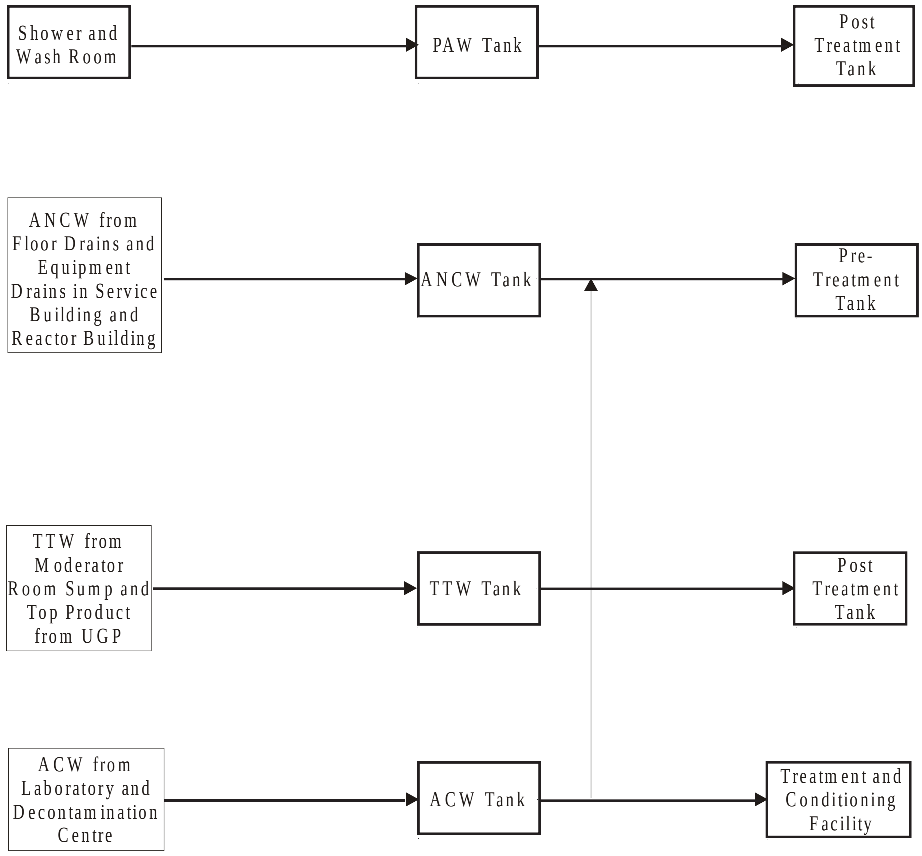



**Legend:**

| | | | | | |
|---|---|---|---|---|---|
| TTW | : | Tritiated Waste | ——— | : | Alternate route |
| LESS | : | Liquid Effluent Segregation System | ACW | : | Active Chemical Waste |
| ANCW | : | Active Non-Chemical Waste | NSDF | : | Near Surface Disposal Facility |
| PAW | : | Potential Active Waste | NDCT | : | Natural Draught Cooling Tower |
| CCW | : | Condenser Cooling Water | IDCT | : | Induced Draught Cooling Tower |
| LW | : | Laundry Waste | | | |

## ANNEXURE-IIIB

## LIQUID EFFLUENT SEGREGATION SYSTEM IN PHWR
## (Refer Sections 5.3.2.2 and 6.2.1)

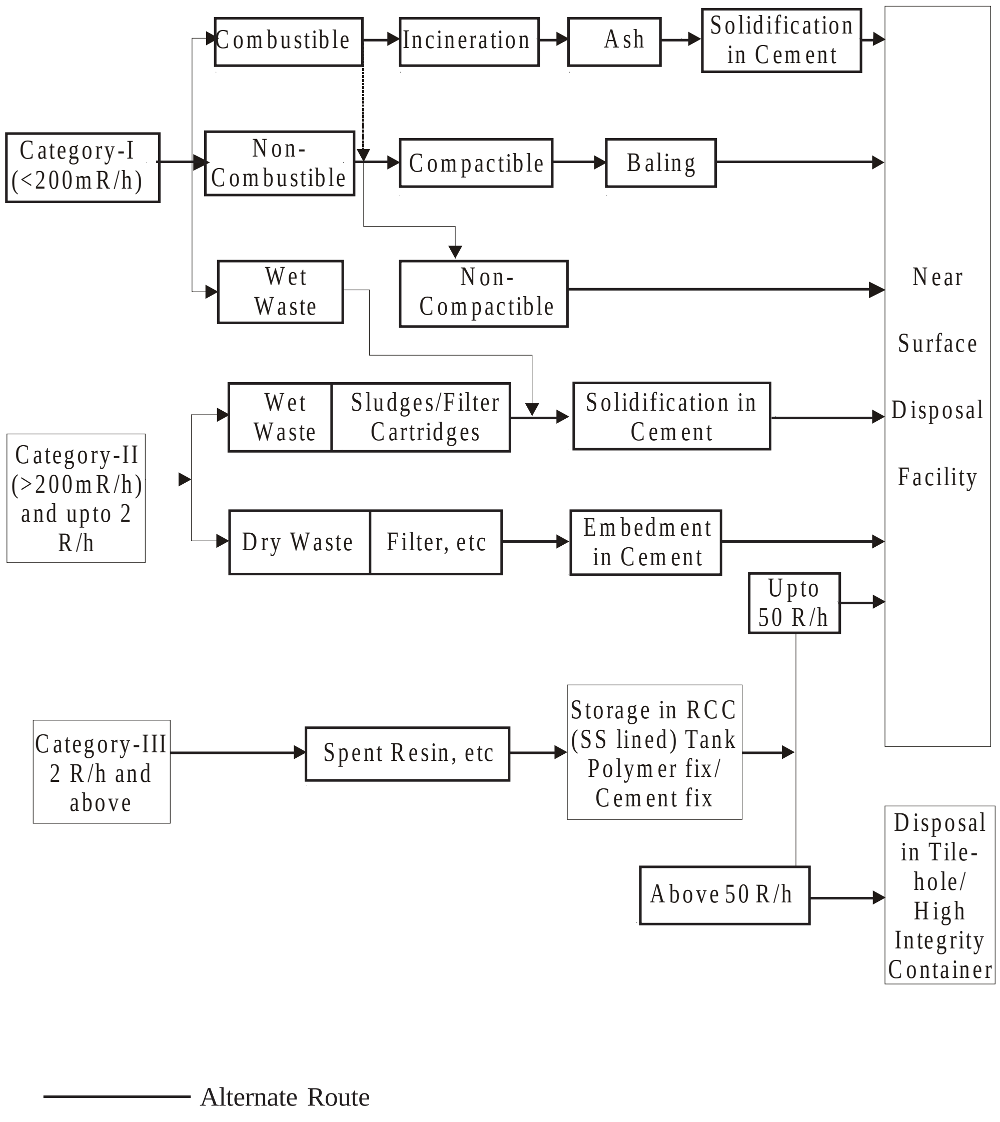



**Legend:**

| | | |
|---|---|---|
| ANCW | : | Active Non-Chemical Waste |
| ACW | : | Active Chemical Waste |
| TTW | : | Tritiated Waste |
| PAW | : | Potential Active Waste |
| UGP | : | Upgrading Plant |

## ANNEXURE-IIIC

### PROCESS SCHEMATIC FOR PHWR SOLID WASTE MANAGEMENT
### (Refer Sections 5.2 and 6.1)



## ANNEXURE-IV A

(To be filled in Triplicate)

**TYPICAL FORMAT FOR COLLECTION OF LIQUID WASTE**
**(Refer Section 10.2.1)**

Ref. No.____________

From :_____________________ Section________________Date____________

| Sr. No | Origin of Waste | Description of Waste(*) | Principal Isotopes Present | Waste Volume (m3) | Specific Activity (MBq/m3) | | | Surface Dose (mGy/h) | Location of Disposal |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Alpha | Beta-Gamma | Tritium | | |
| | | | | | | | | | |

Engineer-in-Charge WMP

Health Physicist

Waste Producer (Plant Management)

..........................................................................................................................................

Received the consignment on_______________

Signature of Waste Receiver________________
(of WMP)

* Note:

1 State the strength of acidity/alkalinity wherever applicable.

2 State whether the liquid is aqueous or organic or contains any detergents.

3. Specify any special precautions to be taken during transport, storage and handling of these waste.

Copy # 1 : for Engineer-in-Charge, WMP

Copy # 2 : for Waste Receiver

Copy # 3 : for Waste Producer

## ANNEXURE-IV B

(To be filled in Triplicate)

**TYPICAL FORMAT FOR COLLECTION OF SOLID WASTE**
**(Refer Section 10.2.1)**

Ref. No._____________

From :_______________________Section_________________Date_________

| Sr. No. | Origin of Waste | Description of Waste (*) | Principal Isotopes Present | Quantity of Waste in kg or $m^3$ as Applicable | Type of Activity: Alpha, Beta, Gamma | Activity Contents MBq | Nature of Waste Compac-tible/ Combus-tible | Surface Dose (mGy/h) | Location of Disposal |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |

Certified that the surface of the container is free from loose contamination and it does not contain any pyrophoric substances.

| | | |
|---|---|---|
| Engineer-in-Charge WMP | Health Physicist | Waste Producer (Plant Management) |

.................................................................................................................................................

Received the consignment on_______________

Signature of Waste Receiver________________
(of WMP)

* Note:

1. Specify any special precautions to be taken during transport, storage and handling of these waste.
2. Specify about the chemical nature, pH, neutralising agents used, valuable/resaleable material details, if any.
3. Indicate nature of waste viz. cotton/paper/wood/mops or rubber/plastics or glasswares or metallic scraps or others, like process equipment, chemical sludges, resin filter, pyropheric substances, etc.

# ANNEXURE-IV C

**Form III**
**Government of India**
**Atomic Energy Regulatory Board**

**RECORD OF RADIOACTIVE WASTES DISPOSED OFF/TRANSFERRED**

Under GSR-125- Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987 - Rule 6 (ii)

Month___________Year _________

1. Address of the Installation :

2. Authorisation No: _____________

3. Particulars of Radioactive Wastes Disposed off by the Installation itself:

| A. Solid Waste | Waste Particulars | Packaging/ Container | Method of Conditioning ($m^3$ ) | Volume Present | Radionuclides Activity (MBq) | Total Disposal | Mode of Disposal Site | Location of |
|---|---|---|---|---|---|---|---|---|
| Category-I | | | | | | | | |
| Category II | | | | | | | | |
| Category III | | | | | | | | |
| Category IV | | | | | | | | |
| B. Liquid Waste | | | | | | | | |
| C. Gaseous Waste | | | | | | | | |

Remarks:

Signature and seal of the Authorised Officer

## ANNEXURE-IV C (contd)

4. Address of the Agencies to whom Radioactive Waste were Transferred:

(i) (ii) (iii)

5. Particulars of Radioactive Solid Wastes Transferred:

| Category | Waste Particulars | Packaging/Container | Volume ($m^3$) | Radionuclides Present | Total Activity (MBq) | Mode of Transfer | Transfer Agency No. | Remarks if any |
|---|---|---|---|---|---|---|---|---|
| I | | | | | | | | |
| II | | | | | | | | |
| III | | | | | | | | |
| IV | | | | | | | | |

6. Particulars of Radioactive Liquid Wastes Transferred:

| Category | Waste Particulars | Packaging/Container | Volume ($m^3$) | Radionuclides Present | Total Activity (MBq) | Mode of Transfer | Transfer Agency No. | Remarks if any |
|---|---|---|---|---|---|---|---|---|
| I | | | | | | | | |
| II | | | | | | | | |
| III | | | | | | | | |
| IV | | | | | | | | |
| V | | | | | | | | |

Observations of AERB Inspection Official

Signature and seal of the Authorised Officer

# ANNEXURE-IVD

**Form IV**
**Government of India**
**Atomic Energy Regulatory Board**

**QUARTERLY/HALF YEARLY/ANNUAL RETURN OF RADIOACTIVE WASTE DISPOSAL/TRANSFER**
Under GSR-125-Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987 - Rule 6 (vi)

Period from ___________ to ______________

1. Address of the Installation:

2. Authorisation No: ___________

3. Address of the Agencies to whom Radioactive Waste were Transferred:

(i) (ii) (iii)

4. Details of Environmental Surveillance Pertaining to Disposal of Waste by the Installation itself:

| | Analysis of Ground Water Samples | Analysis of Soil Samples | Analysis of Air Samples | Remarks |
|---|---|---|---|---|
| Date(s) of measurement | | | | |
| Location(s) of sampling | | | | |
| Average activity concentration | | | | |
| Maximum activity concentration | | | | |

For official use in AERB
Report received on:
Report reviewed on:
Remarks:

To
Chairman, AERB

Signature and seal of the Authorised Officer

# ANNEXURE-IVD (contd.)

Notes

a) This form is meant for report to AERB the disposal/transfer of radioactive waste by the installation.

b) This form is to be submitted to AERB within one month of the expiry of the period specified in the authorisation issued by the competent authority under these rules.

c) Categorisation of solid waste shall be as follows:

| Category | Radiation Dose (D) on the Surface of Waste Package | | Remarks |
|---|---|---|---|
| | R/h | mGy/h (approximately) | |
| I | D £ 0.2 | D £ 2 | |
| II | 0.2 < D £ 2 | 2 < D £ 20 | Beta-gamma emitters |
| III | 2 < D | 20 < D | |
| IV | Alpha bearing waste | | Alpha-emitters dominant. Acitivity expressed in $Ci/m^3$ or $Bq/m^3$ |

d) Categorisation of Liquid Waste shall be as follows:

| Category | Activity Level (A)-(Beta-gamma emitters) | | Remarks |
|---|---|---|---|
| | Ci/m3 | Bq/m3 | |
| I | A £ $10^{-6}$ | A £ 3.7 x $10^4$ | |
| II | $10^{-6}$ £ A £ $10^{-3}$ | 3.7 x $10^4$ < A £ 3.7 x $10^7$ | |
| III | $10^{-3}$ < A £ $10^{-1}$ | 3.7 x 107 < A £ 3.7 x $10^9$ | |
| IV | $10^{-1}$ < A £ $10^4$ | 3.7 x $10^9$ < 3.7 x $10^{14}$ | |
| V | $10^4$ < A | 3.7 x $10^{14}$ < A | |

e) Categorisation of Gaseous Waste shall be as follows:

| Category | Activity Level (A)-(Beta-gamma emitters) | | Remarks |
|---|---|---|---|
| | $Ci/m^3$ | $Bq/m^3$ | |
| I | A £ $10^{-10}$ | A £ 3.7 | |
| II | $10^{-10}$ < $10^{-6}$ | 3.7 < A £ 3.7 x $10^4$ | |
| III | $10^{-6}$ < A | 3.7 x $10^4$ < A | |

# ANNEXURE-IVD (contd.)

5. Particulars of Radioactive Waste Disposed off by the Installation itself:

| A. Solid Waste | Waste Particulars | Packaging/ Container | Method of Conditioning | Volume ($m^3$) | Radionuclides Present | Total Activity (MBq) | Mode of Disposal | Location of Disposal Site |
|---|---|---|---|---|---|---|---|---|
| Category-I | | | | | | | | |
| Category-II | | | | | | | | |
| Category-III | | | | | | | | |
| Category-IV | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| B. Liquid Waste | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| C. Gaseous Waste | | | | | | | | |

Remarks :

Signature and seal of the Authorised Officer

## ANNEXURE-IV D (contd)

6. Particulars of Radioactive Solid Wastes Transferred:

| Category | Waste Particular | Packaging/Container | Volume (m3) | Radionuclides Present | Total Activity (MBq) | Mode of Transfer | Transfer Agency No. | Remarks if any |
|---|---|---|---|---|---|---|---|---|
| I | | | | | | | | |
| II | | | | | | | | |
| III | | | | | | | | |
| IV | | | | | | | | |
| V | | | | | | | | |

7. Particulars of Radioactive Liquid Wastes Transferred:

| Category | Waste Particular | Packaging/Container | Volume (m3) | Radionuclides Present | Total Activity (MBq) | Mode of Transfer | Transfer Agency No. | Remarks if any |
|---|---|---|---|---|---|---|---|---|
| I | | | | | | | | |
| II | | | | | | | | |
| III | | | | | | | | |
| IV | | | | | | | | |
| V | | | | | | | | |

Remarks :

Signature and seal of the Authorised Officer

# ANNEXURE -IV E

**Form 1-A** In Duplicate
**Government of India**
**Atomic Energy Regulatory Board**

## APPLICATION FOR AUTHORISATION FOR SPECIAL RADIOACTIVE WASTE DISPOSAL/TRANSFER CAMPAIGNS

Under G S R 125 - Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987- Rule 4

For filling up the application, please see the guidelines given on the backside of this application with respect to parentheses mentioned against an item below:

Reference No and Date

1 Name and address of the installation

2 Waste disposal/transfer authorisation No.

3 Name and address of waste management agency

4 Particulars of radioctive waste (a)

5 Method of conditioning (b)

6 Conditioned waste volume, $m^3$

7 Category of the waste (c)

8 Radionuclides present (d)

9 Total activity, MBq

10 Packaging container (e)

11 Dose rate on the surface of waste package

12 Safety features of waste transfer (f)

13 Mode and date of waste disposal (g)

14 Location of waste disposal site (h)

15 Reference of safety committee which approved the campaign (i)

To

Chairman, AERB
Niyamak Bhavan,
Anushaktinagar,
Mumbai - 400 094

Signature and seal of the
Authorised Officer

AUTHORISATION FOR WASTE DISPOSAL/TRANSFER CAMPAIGN

Pursuant to the Atomic Energy Act, 1962 and the enabling rules made thereunder, and specially the 'Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987', G.S.R.125, and on assessment of the information furnished above by the applicant to dispose off/transfer radioactive wastes listed there in and in conformity with the terms and conditions specified overleaf, authorisation is hereby issued to the applicant/withheld for the reasons mentioned below

Name and Address of the
Authorised Officer.

Competent Authority

**GUIDANCE FOR FILLING UP THE FORM**

a) Waste Particulars shall include the following information :

(i) for solid wastes material constituting the waste, its size and shape and type of chemicals contained of contaminated with e.g. organic/inorganic, flammable/combustible/pyrophoric, etc.,

(ii) for liquid wastes pH, solids (total, dissolved, suspended) and chemicals present e.g. organic, inorganic, flammable, etc.,

b) Conditioning of wastes shall include the treatment given to the waste to bring it in the disposal state/form:

(i) for solid wastes compaction, incineration, fixation in solidifying agents, etc.,

(ii) for liquid wastes-pH adjustment, filtration, dilution, decay, chemical/biological/ion-exchange treatment, evaporation, reverse osmosis, solidification etc.

c) Cateogory of waste shall be as per categorisation of solid and liquid wastes provided by AERB to the installation vide Form I, III and IV under G.S.R. 125 Atomic Energy Rules,1987.

d) The information on radionuclides present shall include concentration of alpha emitters if present in the waste.

e) Packaging/container shall include following information:

(i) for soild wastes-containment material e. g. polythene/PVC/canvas bags; cardboard/wooden boxes and MS drums etc.

(ii) for liquid wastes-underground piping, tanks, carboys, bottles etc.

f) The information on safe transfer of radioactive wastes shall include prominent or built-in safety feature to avoid loss of material/activity to the surroundings.

g) Mode of disposal for radioactive wastes shall include following information:

(i) for solid wastes-earth trenches, RCC trenches, tile holes etc.

(ii) for liquid wastes-sewer, water bodies, solar evaporation ponds etc.

(iii) Date(s) when disposal of radioactive wastes will be carried out.

h) Location of disposal site shall include information regarding location with reference to distances and identification numbers of earth trenches, RCC trenches tile holes etc.

i) Reference of safety committee e.g. plant safety committee, unit safety committee, SARCOP which approved the compaign shall include meeting No. and date. A copy of relevant portions of minutes of the meeting shall be enclosed for ready reference. In case of special wastes transfer campaign, a copy of letter from receving waste managment agency for its consent and operational plans with respect to the campaign shall also be enclosed with this application.

**Terms and Conditions of Authorisation**

a) Application shall be put up by the officer authorised for safe disposal of radioactive waste at the installation to Chairman, AERB.

b) The person authorised shall abide by all the provisions concerning disposal of radioactive waste and radiation protection laid down in:

   (i) the Atomic Energy Act, 1962 (33 of 1962),

   (ii) the Radiation Protection Rules, 1971, and

   (iii) the Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987.

c) The campaign shall comply with all the recommendations of the plant safety committee/ unit safety committee /SARCOP.

d) The authorisation is restricted to the particular special waste disposal/transfer campaign applied for. Another application shall be submitted for another campaign though it may be similar in all respects. Normal waste dosposal/ transfer operations are governed by authorisation issued by the competent authority in Form II.

e) Any unauthorised change in particulars from that given in the application or nonadherence to the recommendations shall constitute a breach of the authorisation. Completion of the campaign with or without any violations shall be intimated to the competent authority forthwith.

# ANNEXURE-V

## SOURCES OF RADIAOACTIVE WASTE IN BWRs AND REDUCTION MEASURES
**(Refer Section 5.5.1)**

**V.I Gaseous Waste**

V.I.I Source

V.1.1.1 Gaseous waste arise mainly from nuclear steam supply system (NSSS) and contain activation products of coolant such as N-13, N-16, N-17 and O-l 9 in gaseous form and fission product noble gases and radio-iodines primarily, if there are clad defects. The FPNG consists of radioisotopes of Krypton and Xenon with half-lives ranging from one second to a few years. Source for radioiodine releases are mainly from hot and high pressure primary coolant leaks. Primary steam leaks mainly contribute to participate activity releases. All gaseous releases are routed through the stack.

V.1.1.2 The activation products and FPNG, if any, are swept with primary steam, and they being non-condensable, are removed by steam jet air ejector system at the main condenser and are released through the stack after a 30 minute holdup (for decay of short-lived radionuclides) and filtration through HEPA filters. Turbine gland sealing system exhaust and contaminated ventilation air are additional sources of gaseous waste though their contribution is very small.

V.1.2 Reduction Measures

V.1.2.1 The generation of gaseous and particulate activity and their releases should be kept as low as practicable. A few measures to achieve low generation and low release are:

i) maintain good fuel performance,

ii) minimise primary coolant and steam leaks,

iii) keep air-in-leakage into the condenser low to minimise off gas flow rate and thereby optimize hold-up decay time,

iv) minimise dry well venting and vent system,

v) ensure efficient performance of HEPA filters for off-gas, and

vi) operation of secondary steam generator with tube leaks should be avoided. However, secondary steam generators when operated with tube leaks, it is necessary to ensure proper performance of demister on blowdown tank and also minimise frequency of blowdown by ensuring required feed input water quality.

**V.2 Liquid Waste**

Liquid radioactive waste generated at BWRs are mainly segregated into two streams, namely, waste from equipment drain system called as clean radioactive waste (CRW) and waste from floor drain system called as dirty radioactive waste (DRW). These are described as follows:

V.2.1 Clean Radioactive Waste (CRW)

V.2.1.1 This is low conductivity higher specific activity waste consisting of leaks mainly from primary coolant boundary and spent fuel storage bay systems. Such waste is processed through pressure precoat filters and or by mixed bed demineraliser.

V.2.1.2 Major sources for CRW are:

i) system leaks (both from primary coolant boundary and steam/feed cycle including secondary steam generators),

ii) leaks/rejects from fuel pool system,

iii) dry well-leaks,

iv) secondary steam generator blowdown, and

v) CRW sump in RB sump.

V.2.2 Duty Radioactive Waste (DRW)

V.2.2.1 This category of liquid waste stream is of high conductivity and low specific activity. It is further subdivided into floor drain waste and active chemical regeneration waste arising from regeneration of radwaste demineraliser, used for processing of CRW and condensate demineraliser. It is the stream which mainly contributes to liquid waste discharges in BWRs. Filtration, chemical treatment, evaporation, use of ceasium specific (Cs) ion-exchangers, etc. are the methods of treatment used for reducing the radionuclide content prior to disposal.

V.2.2.2 Major sources for DRW are:

- i) regeneration waste arising from radwaste demineraliser/ regeneration of condensate polishing demineralisers,
- ii) laundry detergent waste including drains from personnel de-contamination showers/ wash basins,
- iii) equipment decontamination solutions,
- iv) processing of supermate from spent resin storage tank, and
- v) intermixing of different waste streams (e.g. leaks in regeneration facility, radwaste system-particularly filter sludge storage system, spent resin handling/processing systems, mix-up of CRW and DRW due to sump overflow, etc.).

V.2.3 Reduction Measures

V.2.3.1 The following measures should be employed to reduce the waste generation:

- i) operating the reactor in a manner so that fuel failures are minimised,
- ii) reducing leakages from primary coolant system and other systems,
- iii) planning and execution of maintenance work on contaminated systems/equipment using trained manpowers and approved procedures,
- iv) operation of condensate and radwaste demineralisers with proper quality of resins, keeping appropriate cation to anion ratio to minimise regeneration frequency,
- v) resins from radwaste demineraliser may be used in once through operations and the spent resins after conditioning are disposed off as solid waste; and
- vi) adherence to well established operating practices.

# ANNEXURE-VI

## TYPICAL DATA ON WASTE ARISING FROM COOLANT CHANNEL REPLACEMENT OPERATIONS IN PHWR BASED NPP (Refer Section B.2.6)

VI.1 A typical data on 220 MWe PHWR reactor components that are involved in the coolant channel replacement campaign are given in the following table:

| Sl. No. | Item Name | Quantity (Nos.) | Approximately Weight (Te) (Total) | Dimensions (lenght in m and thickness in cm) | Calculated Dose Rate (R/h) | Actual Dose Measured (*) (R/h) |
|---|---|---|---|---|---|---|
| 1. | Coolant Tubes | 306 | 11.8 | 5.4 x 9.0 | 800 | 270-799 |
| 2. | End Fittings | 612 | 150 | 2.1 x 15.0 | 400 | 250-700 |
| 3. | Garter Springs | 612 | 0.1 | 0.3 x 1.0 | 30 | 20-60 |
| 4. | Shield Plugs | 612 | 30 | 1.0 x 8.3 | 20 | 20-30 |

*After 1.5 years cooling time period.

VI.2 The major radionuclides of concern along with their specific activities that are expected in a 1.5 years cooled PHWR coolant channel are given in the following table:

| Sl. No. | Radionuclide | Specific Activity (MCi/g) | Half-Life |
|---|---|---|---|
| 1 | Sb-125 | 0.0155 | 2.70 days |
| 2. | Zr-95 | 0.0015 | 65.5 days |
| 3. | Nb-95 | 0.0027 | 35.5 days |
| 4. | Co-60 | 0.0013 | 5.3 years |
| 5. | Co-58 | - | 71 days |
| 6. | Mn-54 | - | 303 days |
| 7. | Fe-59 | - | 45 days |
| 8. | Cr-51 | - | 27.8 days |

# BIBLIOGRAPHY


1. ATOMIC ENERGY REGULATORY BOARD, 'Code of Practice on Safety in Nuclear Power Plant Operation', AERB Code No. SC/O, Mumbai, India (1989).
2. INTERNATIONAL ATOMIC ENERGY AGENCY, Safety Guide on 'Operational Management of Radioactive Effluents and Waste Arising in Nuclear Power Plants', 50-SG-O-11 (1986).
3. ATOMIC ENERGY REGULATORY BOARD, 'Code of Practice on Quality Assurance for Safety in Nuclear Power Plants', AERB Code No. SC/QA, Mumbai, India (1988).
4. INTERNATIONAL ATOMIC ENERGY AGENCY, 'Management of Radioactive Waste from Nuclear Power Plants', Safety Series, SS-69 (1985).
5. INTERNATIONAL ATOMIC ENERGY AGENCY, 'Principles for Limiting Releases of Radioactive Effluents into the Environment', Safety Series, SS-77 (1986).
6. INTERNATIONAL ATOMIC ENERGY AGENCY, 'Design of Radioactive Waste Management Systems at Nuclear Power Plants', Safety Series, SS-79 (1986).
7. Atomic Energy Act, 1962, GSR-125, Atomic Energy (Safe Disposal of Radioactive Waste), Rule (vi) (1987).
8. Atomic Energy (Factories) Rules (1996).
9. ATOMIC ENERGY REGULATORY BOARD, Safety Manual on 'De-commissioning of Nuclear Facilities', AERB/SM/DECOM-1, Mumbai, India (1998).
10. ATOMIC ENERGY REGULATORY BOARD, Safety Guide on 'Radiation Protection During Operation of Nuclear Power Plants', AERB/SG/O-5, Mumbai, India (1995).

## LIST OF PARTICIPANTS

## WORKING GROUP

| | | |
|---|---|---|
| Dates of meeting: | February 18, 1993 | August 21 & 22, 1995 |
| | March 10, 1993 | September 28 & 29, 1995 |
| | May 17, 18 & 19, 1993 | October 17 & 18, 1995 |
| | October 8, 1993 | October 9, 10 & 11, 2000 |
| | November 1, 1993 | October 19, 2000 |
| | June 28 & 29, 1995 | October 30 & 31, 2000 |

**List of Participants:**

| | | |
|---|---|---|
| Shri S.S.Ali (Chairman) | : | BARC (from 1996 onwards) |
| Shri C.Kumar | : | MAPS, NPCIL (upto April 2000) |
| Shri N.B.Joshi | : | NPCIL |
| Shri K.Banerjee | : | BARC (up to June 1996) |
| Shri S.B.Guha | : | NPCIL (from 1996 onwards) |
| Shri R.C.Rastogi (Invitee) | : | Ex-IAEA (from January 2000 onwards) |
| Shri D.K.Dave (Invitee) | : | AERB |
| Shri K.K.Chandraker (Invitee) | : | AERB (from January 2000 onwards) |
| Dr. P.Vijayan (Invitee) | : | AERB |
| Shri S.T.Swamy (Member-Secretary) | : | AERB |

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| | | |
|---|---|---|
| Dates of meeting: | August 29, 1997 | March 26, 1999 |
| | October 25, 1997 | April 22 & 23, 1999 |
| | May l3 &14, 1998 | August 28, 1999 |
| | October 9 & 10, 1998 | November 9 & 10, 2000 |

**Members of ACCGASO:**

| | | |
|---|---|---|
| Shri G.V.Nadkarny (Chairman) | : | NPCIL (Former) |
| Shri T.S.V.Ramanan | : | NPCIL (upto 1998) |
| Shri K.M.Sinha | : | NPCIL |
| ShriY.K.Joshi | : | RAPS/NPCIL |
| Shri Ravindranath | : | TAPS/NPCIL |
| Shri V.V.Sanathkumar | : | Kaiga/NPCIL |
| Shri R.S.Singh | : | AERB (up to October 2000) |
| Shri Ram Sarup | : | AERB |
| Shri S.T.Swamy (Co-opted) | : | AERB |
| Shri S.K.Warrier (Member-Secretary) | : | AERB |

## ADVISORY COMMITTEE ON NUCLEAR SAFETY (ACNS)

| | |
|---|---|
| Dates of meeting: | September 30, 2000<br>February 24, 2001 |

Members of ACNS:

| | | |
|---|---|---|
| Shri S.K.Mehta (Chairman) | : | BARC (Former) |
| Shri S.M.C. Pillai | : | Nagarjuna Group,<br>Hyderabad |
| Prof. U.N.Gaitonde | : | IIT, Bombay |
| Shri S.K.Goyal | : | BHEL |
| Shri Ch.Surendar | : | NPCIL (Former) |
| Shri S.K.Sharma | : | BARC |
| Dr. U.C.Mishra | : | BARC (Former) |
| Dr. V.Venkat Raj | : | BARC |
| Shri S.P.Singh | : | AERB (Former) |
| Shri G.K.De | : | AERB (Former) |
| Shri K.Srivasista (Member-Secretary) | : | AERB |

## PROVISIONAL LIST OF SAFETY CODES, GUIDES AND MANUAL ON OPERATION OF NUCLEAR POWER PLANTS

| Safety Series No. | Provisional Title |
|---|---|
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| AERB/SG/O-1 | Staffing, Recruitment, Training, Qualification and Certification of Operating Personnel of Nuclear Power Plants |
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| AERB/NPP/SG/O-15 | Proof and Leakage Rate Testing of Reactor Containments |
| AERB/NF/SM/O-1 | Probabilistic Safety Assessment Guidelines |

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