CODE NO. AERB/NPP/SC/O (Rev. 1)

GOVERNMENT OF INDIA

AERB SAFETY CODE

NUCLEAR POWER PLANT OPERATION

ATOMIC ENERGY REGULATORY BOARD

AERB SAFETY CODE NO. AERB/NPP/SC/O (Rev. 1)

NUCLEAR POWER PLANT OPERATION

Approved by the Board on September 12, 2008

Atomic Energy Regulatory Board
Mumbai-400 094
India

December 2008

Price

Orders for this code should be addressed to:

The Administrative Officer
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FOREWORD

Activities concerning establishment and utilisation of nuclear facilities and use of radioactive sources are to be carried out in India in accordance with the provisions of the Atomic Energy Act 1962. In pursuance of the objective of ensuring safety of members of the public and occupational workers as well as protection of environment, the Atomic Energy Regulatory Board (AERB) has been entrusted with the responsibility of laying down safety standards and enforcing 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. While some of the documents cover aspects such as siting, design, construction, operation, quality assurance and decommissioning of nuclear and radiation facilities, other documents cover regulatory aspects of these facilities.

Safety codes and standards are formulated on the basis of nationally and internationally accepted safety criteria for design, construction and operation of specific equipment, structures, systems and 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, 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.

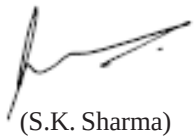
AERB Safety Code on 'Nuclear Power Plant Operation' (AERB/NPP/SC/O) lays down the requirements for safe operation of Nuclear Power Plant to ensure protection of the public, environment and the site personnel from any undue radiological consequences, prevention of accident conditions and mitigation of the consequences of any accident in the unlikely event of its occurrence. In drafting this code, extensive use has been made of the information contained in the relevant IAEA safety standards. This code is revision of 1989 edition of Code of Practice on Safety in Nuclear Power Plant Operation (AERB/SC/O). This revision is issued to reflect developments that have taken place since then. Specifically, aspects of new requirements arising out of operational safety experience feedback, renewal of authorisation, plant life management and probabilistic safety assessment are included.

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

This code applies only for nuclear power plants built after the issue of the document. However during periodic safety review, a review for applicability of the current code for existing facilities would be performed.

This code has been prepared by specialists in the field drawn from Atomic Energy Regulatory Board, Bhabha Atomic Research Centre, Indira Gandhi Centre for Advanced Research, Nuclear Power Corporation of India Limited and an experienced consultant. Experts have reviewed the Code and the relevant AERB Advisory Committee on Codes, Guides and Associated Manuals for Safety in Operation of Nuclear Power Plants and Advisory Committee on Nuclear Safety have vetted it before issue.

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



(S.K. Sharma)
Chairman, AERB

DEFINITIONS

Acceptable Limits

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

Acceptance Criteria

The standard or acceptable value against which the value of a functional or condition indicator is used to assess the ability of a system, structure or component to perform its design function or compliance with stipulated requirements.

Accident

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

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.

Ageing

General process in which characteristics of structures, systems or components gradually change with time or use [although the term 'ageing' is defined in a neutral sense - the changes involved in ageing may have no effect on protection or safety, or could even have a beneficial effect - it is commonly used with a connotation of changes that are (or could be) detrimental to protection or safety, i.e. as a synonym of 'ageing degradation'].

Ageing Management

The engineering, operations and maintenance actions to control ageing degradation and wearing out of systems, structures or components within acceptable limits.

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

Audit

A documented activity performed to determine by investigation, examination and evaluation of objective evidence, the adequacy of, and adherence to applicable codes, standards, specifications, established procedures, instructions, administrative or operational programmes and other applicable documents, and the effectiveness of their implementation.

Authorisation

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

Authorised Limits

(See "Prescribed Limits").

Beyond Design Basis Accidents (BDBA)

Accidents of very low probability of occurrence, more severe than the design basis accidents, those may cause unacceptable radiological consequences; they include severe accidents also.

Certification (of Personnel)

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

Cold Shutdown (Reactor)

Shutdown state in which the temperature of the primary heat transport system at inlet is less than the specific value (e.g. 55 ^{0}C for PHWRs.)

Collective Dose

An expression for the total radiation dose incurred by a population and defined as the product of the number of individuals exposed to a source and their average radiation dose.

Commencement of Operation of Nuclear Power Plant

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 or radiation facility, on being constructed, are made functional and verified in accordance with design specifications and found to have met the performance criteria.

Component

The smallest part of a system necessary and sufficient to consider for system analysis.

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.

Consentee

A person to whom consent is granted by the competent authority under the relevant rules.

Construction

The process of manufacturing, testing and assembling the components of a nuclear or radiation facility, the erection of civil works and structures, the installation of components and equipment and the performance of associated tests.

Controlled Area

A delineated area to which access is controlled and in which specific protection measures and safety provisions are, or could be, required for

(a) controlling normal exposures or preventing the spread of contamination during normal working conditions; and

(b) preventing potential exposures or limiting their extent should they occur.

Core Components

All items other than fuel, which reside in the core of a nuclear power plant and have a bearing on fuel integrity and/or utilisation (e.g. calandria, reactor-vessel, coolant channels, in-core detectors and reactivity devices).

Core Damage

Reactor state brought about by the accident conditions with loss of core geometry or resulting in crossing of design basis limits or acceptance criteria limits for one or more parameters. (The parameters to be considered include fuel clad strain, fuel clad temperature, pressure for primary and secondary systems, fuel enthalpy, clad oxidation, % of fuel failure, H_2 generation from metal-water reaction, radiation dose, time required for operator to take emergency mitigatory action).

Core Management

All activities associated with the use of fuel and core components in a nuclear power plant with the ultimate aim of ensuring integrity and efficient use of the same.

Criteria

Principles or standards on which a decision or judgement can be based. They may be quantitative or qualitative.

Criticality

The 'stage' or 'state' of a fissile material system where a self-sustained nuclear chain reaction is just maintained.

Decommissioning

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

Design

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

Design Basis Accidents (DBAs)

A set of postulated accidents which are analysed to arrive at conservative limits on pressure, temperature and other parameters which are then used to set specifications to be met by plant structures, systems and components, and fission product barriers.

Design Basis Threat (DBT)

The attributes and characteristics of potential insider and/or external adversaries, who might attempt unauthorised removal of nuclear material or sabotage, against which a physical protection system is designed and evaluated.

Design Life

The period for which the item will perform satisfactorily meeting the criteria set forth in the design specification.

Design Limits

Limits on the design parameters within which the design of the structures, systems and components of a nuclear facility have been shown to be safe.

Deterministic Analysis

Analysis using, for key parameters, single numerical values (taken to have probability of 1), leading to a single value of the result.

Documentation

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

Emergency

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

Emergency Exercise

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

Emergency Plan

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

Engineered Safety Features (ESF)

The system or features specifically engineered, installed and commissioned in a nuclear power plant to mitigate the consequences of accident condition and help to restore normalcy, e.g. containment atmosphere clean-up system, containment depressurisation system, etc.

Event

Occurrence of an unplanned activity or deviations from normalcy. It may be an occurrence or a sequence of related occurrences. Depending on the severity in deviations and consequences, the event may be classified as an anomaly, incident or accident in ascending order.

Fuel Handling

All activities relating to receipt, inspection, storage and loading of unirradiated fuel into the core and unloading of irradiated fuel from the core, its transfer, inspection, storage and despatch from the nuclear power plant.

Guaranteed Shutdown State (GSS)

A specified shutdown state of the reactor with sufficiently large reactivity shutdown margin, established by the addition of liquid poison into moderator to provide positive assurance that an inadvertent increase in reactivity by withdrawal of all other reactivity devices cannot lead to criticality.

In-service Inspection (ISI)

Inspection of structures, systems and components carried out at stipulated intervals during the service life of the plant.

Inspection

Quality control actions, which by means of examination, observation or measurement, determine the conformance of materials, parts, components, systems, structures as well as processes and procedures with predetermined quality requirements.

Item

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

Items Important to Safety (IIS)

The items which comprise:

- those structures, systems, equipment and components whose malfunction or failure could lead to undue radiological consequences at plant site or off-site;
- those structures, systems, equipment and components which prevent anticipated operational occurrences from leading to accident conditions;
- those features which are provided to mitigate the consequences of malfunction or failure of structures, systems, equipment or components.

Level 1 PSA (Nuclear Reactor)

It evaluates core damage frequency by developing and quantifying accident sequences (event trees) with postulated initiating events together with system unavailability values derived from fault tree analyses with inputs from failure data on components, common causes and human actions.

Level 2 PSA (Nuclear Reactor)

It takes inputs from Level 1 PSA results and quantifies the magnitude and frequency of radioactive release to the environment following core damage progression and containment failure.

Level 3 PSA (Nuclear Reactor)

Taking inputs from Level 2 analysis, it evaluates frequency and magnitude of radiological consequences to the public, environment and the society considering meteorological conditions, topography, demographic data, radiological release and dispersion models.

Licence

A type of regulatory consent, granted by the regulatory body for all sources, practices and uses for nuclear facilities involving the nuclear fuel cycle and also certain categories of radiation facilities. It also means authority given by the regulatory body to a person to operate the above said facilities (see ''Licenced Person'' and ''Licenced Position'').

Licenced Person

A person who has been licenced to hold certain licensed position 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 person certified by the regulatory body or a body, designated by it.

Limit

The value of a parameter or attribute (which is variable) used in certain specific activities or circumstances that must not be exceeded.

Limiting Conditions for Operation (LCO)

Conditions that are imposed on operation which are intended to ensure safety during startup, normal operation and shutdown. They also help to avoid reaching the limiting safety system settings and ensure readiness for performing necessary functions in the event of an accident. LCO include limits of operating parameters, requirements of minimum operable equipment of various systems, minimum specified staffing as well as prescribed actions to be taken by operating staff.

Limiting Safety System Settings (LSSS)

Settings on instrumentation, which initiate the automatic protection action at a level such that the safety limits are not exceeded.

Maintenance

Organised activities covering all preventive and remedial measures, both administrative and technical, to ensure that all structures, systems and components are capable of performing as intended for safe operation of the plant.

Normal Operation

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

Nuclear Facility

All nuclear fuel cycle and associated installations encompassing the activities from the front end to the back end of nuclear fuel cycle processes and also the associated industrial facilities such as heavy water plants, beryllium extraction plants, zirconium plants, etc.

Nuclear Fuel Cycle

All operations associated with the production of nuclear energy, including mining, milling, processing and enrichment of uranium or processing of thorium, manufacture of nuclear fuel, operation of nuclear reactors, reprocessing of irradiated nuclear fuel,

decommissioning, and any activity for radioactive waste management and research or development activity related to any of the foregoing.

Nuclear Material

Plutonium, except that with isotopic concentration exceeding 80% in plutonium-238, uranium-233, uranium enriched in the isotope 235, irradiated fuel (depleted or natural uranium, thorium or low enriched fuel of less than 10% fissile content), uranium containing the mixture of isotopes as occurring in nature other than in the form of ore or ore-residue and any material containing one or more of the foregoing.

Nuclear Power Plant (NPP)

A nuclear reactor or a group of reactors together with all the associated structures, systems, equipment 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.

Nuclear Security

All preventive measures taken to minimise the residual risk of unauthorised transfer of nuclear material and/or sabotage, which could lead to release of radioactivity and/or adverse impact on the safety of the plant, plant personnel, public and environment.

Occupational Worker

Any person, working full time or part time in a nuclear or radiation facility, who may be employed directly by the "consentee" or through a contractor.

Off-site Emergency

Accident condition/emergency situation involving excessive release of radioactive materials/hazardous chemicals from the plant to the public domain calling for intervention.

Off-site Emergency Director (OED)

A specifically designated officer (for instance, the Collector/District Magistrate) with adequate legal authority to control and coordinate all off-site emergency measures in the public domain.

Operating Personnel

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

Operating State

The state when an entity performs a required function.

Operation

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

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 (see also 'Technical Specifications for Operation').

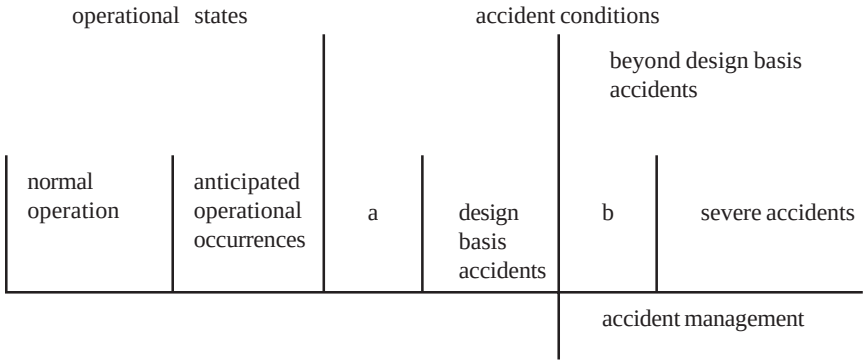
Plant Emergency

Declared emergency conditions in which the radiological/other consequences, confined to the plant or a section of the plant, requiring immediate operator action.

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.

Plant States



a = Accident conditions which are not explicitly considered as design basis accidents, but are enveloped by them.

b = Beyond design basis accidents without significant core degradation.

- Accident conditions include all non-operational states, rather than just design basis accidents and those enveloped by them (marked as 'a');
- The category, marked 'b', of beyond design basis accidents which are not classified as severe accidents because there is no significant core degradation; and

- The term accident management is applied only to beyond design basis accidents, rather than all non-operational states.

Power Operation

Operation at a power level exceeding the conditional trip values as stipulated by the regulatory body for plant operation.

Practice

Any human activity that introduces additional sources of exposure or exposure pathways or extends exposure to additional people or modifies the network of exposure pathways from existing sources, so as to increase the exposure or the likelihood of exposure of people, or the number of people exposed.

Prescribed Limits

Limits established or accepted by the regulatory body.

Prescribed Substance

Any substance including any mineral which the Central Government may, by notification, prescribe, as being a substance which, in its opinion may be used for the production or use of atomic energy or research into matters connected therewith and includes uranium, plutonium, thorium, beryllium, deuterium or any of the respective derivatives or compounds or any other materials containing any of the aforesaid substances.

Pre-Service Inspection (PSI)

The inspection performed prior to or during commissioning of the plant to provide data on initial conditions supplementing manufacturing and construction data as a basis for comparison with subsequent examinations during service.

Preventive Maintenance

Maintenance carried out at predetermined intervals or according to prescribed criteria and to reduce the probability of failure or the degradation of the functioning of an entity.

Probabilistic Safety Assessment (PSA)

A comprehensive structured approach to identifying failure scenarios constituting a conceptual and mathematical tool for deriving numerical estimates of risk.

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 (QA)

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

Radiation Worker

Any person who is occupationally exposed to radiation and who in the opinion of the regulatory body should be subjected to radiation surveillance.

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.

Reactor Trip

Actuation of a shutdown system to bring the reactor to shutdown state.

Reactor Trip (Absolute)

That comes into action at all reactor power levels.

Reactor Trip (Conditional)

That comes into action when reactor power is at or above the specified value approved by the regulatory body.

Records

Documents, which furnish objective evidence of the quality of items and activities affecting quality. They include logging of events and other measurements.

Regulatory Body

(See "Atomic Energy Regulatory Board").

Regulatory Clearance

A type of regulatory consent, which is issued for a nuclear facility during the intermediate stages of consenting process.

Regulatory Consent

(See "Consent").

Reliability

The probability that a structure, system, component or facility will perform its intended (specified) function satisfactorily for a specified period under specified conditions.

Responsible Organisation

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

Review

Documented, comprehensive and systematic evaluation of the fulfillment of requirements, identification of issues, if any.

Risk

A multi-attribute quantity expressing hazard, danger or chance of harmful or injurious consequences associated with an actual or potential event under consideration. It relates to quantities such as the probability that the specific event may occur and the magnitude and character of the consequences.

Root Cause

The fundamental cause of an event, which, if corrected, will prevent its recurrence, i.e. the failure to detect and correct the relevant latent weakness(es) (undetected degradation of an element of a safety layer) and the reasons for the failure.

Safety

(See "Nuclear Safety").

Safety Analysis

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

Safety Analysis Report (SAR)

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

Safety Assessment

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

Safety Code

A document stating the basic requirements, which must be fulfilled for particular practices or applications. This is issued under the authority of the regulatory body and mandatory to be followed by the respective utilities.

Safety Culture

The assembly of characteristics and attitudes in organisations and individuals which establishes that as an overriding priority, the protection and safety issues receive the attention warranted by their significance.

Safety Guide

A document containing detailed guidelines and various procedures/ methodologies to implement the specific parts of a safety code, that are acceptable to the regulatory body, for regulatory review. This is issued under the authority of regulatory body and is of non-mandatory nature.

Safety Limits

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

Safety Manual

A document detailing the various safety aspects/instructions and requirements relating to a particular practice or application, that are to be followed by a utility.

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 site personnel, the public and/or the environment.

Safety Related Systems

Systems important to safety which are not included in "safety systems", and which are required for the normal functioning of the safety systems.

Safety Standard

A document similar to a safety code, elaborating upon the various technical requirements that must be met for a particular practice or application, so as to meet the requirements of the code.

Safety System

System 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 system).

Safety System Settings

The levels at which protective devices are automatically actuated in the event of

anticipated operational occurrences or accident conditions, so as to prevent safety limits being exceeded.

Severe Accident

Nuclear facility conditions beyond those of the design basis accidents causing significant core degradation.

Significant Event

Any event, which degrades system performance function(s) without appreciable damage to either the system or life or limb.

Significant Events (Nuclear Facility)

Unusual occurrences exceeding the limits and conditions stipulated by the regulatory body.

Site

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

Site Emergency

Accidental condition/emergency situation in the plant involving radioactivity transgressing the plant boundary but confined to the site, or involving release of hazardous chemicals or explosion, whose effects are confined to the site, with off-site consequences being negligible.

Site Emergency Director

A specifically designated officer with adequate authority to control and coordinate all site emergency actions.

Site Personnel

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

Siting

The process of selecting a suitable site for a facility including appropriate assessment and definition of the related design bases.

Software (Computer)

The set of instructions that make computer hardware perform certain tasks. Programs, operating systems, device drivers and macros are all different kinds of software.

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.

Structure

The assembly of elements which supports/houses the plants, equipment and systems.

Supervised Area

Any area not designated as a controlled area but for which occupational exposure conditions are kept under review even though specific protective measures and safety provisions are not normally needed.

Surveillance

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

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 facility. It is also called as "operational limits and conditions".

Test

An experiment carried out in order to measure, quantify or classify a characteristic or a property of an entity.

Testing (QA)

The determination or verification of the capability of an item to meet specified requirements by subjecting the item to a set of physical, chemical, environmental or operational conditions.

Validation

The process of determining whether a product or service is adequate to perform its intended function satisfactorily.

CONTENTS

1. INTRODUCTION

1.1 General

Safe functioning of a nuclear power plant (NPP) is ensured by proper siting, design, construction and commissioning together with its proper management and operation. This safety code deals with various aspects necessary for the safe operation of an NPP, and its later decommissioning and requirements for the same.

This code supersedes the earlier version AERB/SC/O, 1989. This revised code reflects the later developments that have taken place in various areas of operational safety and includes important requirements covered in safety guides, already issued. Operational safety experience feedback, renewal of authorisation after periodic safety review, plant life management and probabilistic safety assessment are also included.

Guidance on fulfillment of the requirements of this code may be found in appropriate safety guides/manuals.

1.2 Objective

The objective of the code is to establish the minimum requirements that shall be met to ensure:

(i) protection of site personnel, members of the public and the environment from undue radiological consequences arising from the operation of NPPs;

(ii) prevention of any situation which might lead to an accident condition; and

(iii) mitigation of the consequences of any accident, if it occurs.

1.3 Scope

This code is applicable to land-based, stationary NPPs and is primarily addressed to aspects, which are directly related to safe operation of an NPP. Matters relating to industrial safety and fire safety are not covered in this code. These are separately dealt with elsewhere.

The principles stated herein can also be usefully employed for other facilities including research reactors.

2. REGULATORY BODY

2.1 The regulatory body, Atomic Energy Regulatory Board (AERB) issues regulatory consents for siting, construction, commissioning, operation and decommissioning of nuclear facilities under its purview including NPPs. AERB monitors and, when considered necessary, enforces regulatory requirements to assure fulfillment of nuclear safety, radiation protection, nuclear security and industrial safety objectives during the performance of activities authorised by it.

2.2 AERB will require the following to be met by the responsible organisation (RO)/ plant management (PM)

(i) Submission of the necessary documents and information for authorisation and monitoring;

(ii) Facilitate access to the NPP and documentation;

(iii) Undertake special analyses, tests and inspections.

2.3 In view of the responsibility for safe operation of the NPPs, if in opinion of the RO/PM, a particular stipulation of AERB could have an adverse effect on safety, the RO/PM shall refer the matter to AERB for reconsideration. AERB will give due consideration to such opinions, if any, and take a decision on the matter.

2.4 The relationship between the AERB and the RO/PM shall be frank, open and yet formal with mutual understanding and respect.

3. RESPONSIBLE ORGANISATION

3.1 The RO, as consentee, shall have overall responsibility for the safe and efficient operation of the NPPs.

3.2 The RO shall establish and implement policies so that safety and nuclear security aspects are given the highest priority.

3.3 The RO shall ensure that design is in accordance with the provisions in relevant codes established by or acceptable to AERB and enable the plant to be operated safely and has design provision for decommissioning. The design shall address feedback from operational experience and requirements of maintenance and in-service inspection.

3.4 The RO shall ensure that NPP is constructed in accordance with the approved design and the quality assurance (QA) requirements.

3.5 The RO shall clearly define in writing the functional responsibilities, levels of delegated authority and lines of internal and external communication for the safe operation of the plants in all operational states, for mitigating the consequences of accident conditions and for ensuring an appropriate response in emergencies.

3.6 The objectives of the RO shall be to ensure that:

(i) the NPP is tested for specified requirements as per approved procedures to demonstrate that the design and construction requirements have been met and the NPP can be operated in accordance with design assumptions and intent as relevant to safety;

(ii) the operation of the NPP is carried out in accordance with design assumptions and intent by authorised persons who are adequately trained for their functions including coping with emergency situations/ abnormal conditions;

(iii) all activities pertaining to the operation of the NPP are carried out in a planned and systematic manner and in accordance with the QA programme;

(iv) adequate facilities and services are available in time both for normal operation and during emergency situations;

(v) continued protection is provided to the occupational workers , the public and the environment from radiological or other potential hazards during the lifetime of the NPP, till a certificate for the termination of the responsibilities for that site is obtained from AERB; and

(vi) documentation in respect of the NPP is completed at defined stages.

3.7 To meet the objectives directly related to the operation of the NPP, the responsibility of RO shall include:

(i) establishing the plant organisation with required authority, self-sufficiency and autonomy for operating the NPP ;

(ii) providing necessary support services and facilities to the PM from time to time for effective implementation of its programmes and for ensuring safe operation of the NPP ;

(iii) review of the functioning of the PM in respect of objectives for ensuring safe operation of the NPP in order to meet requirement of this code;

(iv) establishing of management programmes relating to operation review and audit with the aim of ensuring that an appropriate safety consciousness and safety culture prevails;

(v) establishing liaison with public authorities and AERB for the purposes of considering and understanding their requirements for compliance;

(vi) establishing liaison with design, construction, manufacturing and other organisations to ensure proper transfer of information and experience;

(vii) providing adequate training to personnel; and

(viii) establishing radioactive waste management programme in compliance with the requirements of Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, Government Statutory Rules (GSR-125), Atomic Energy (Radiation Protection) Rules, 2004 in force and AERB safety code on 'Management of Radioactive Waste'(AERB/NRF/SC/RW).

3.8 While reviewing plant performance, where practicable, suitable objective performance monitoring measures shall be used. The results shall be made available to PM and appropriate corrective actions shall be taken.

3.9 In establishing organisational structure, the following main categories of RO management functions applicable in various degrees at all levels shall be considered:

(i) policy-making functions;

(ii) operating functions;

(iii) supporting functions including technical support; and

(iv) reviewing functions.

3.10 Organisation charts depicting the overall RO structure and the PM structure shall be prepared to ensure that there is no ambiguity in assigning primary responsibility and in the delineation of line of authority and communications. The interface with AERB shall be included in the above charts.

3.11 The RO shall submit or make available documents and information in accordance with the requirements of AERB.

3.12 The RO shall have arrangements to use the operational safety experience feedback for implementation of preventive/corrective actions and for identification of good practices.

3.13 The RO shall have arrangement for life management from site selection to the end of operating phase of the NPP to achieve safe operation through its life, conforming to regulatory requirements and providing designated design support throughout the life.

4. PLANT MANAGEMENT

4.1 The PM, as consentee, shall have the primary responsibility for the safe operation of the NPP.

4.2 The PM structure shall provide for performance of all functions having an immediate bearing on the safe operation of the plant. The duties and responsibilities for such function shall be clearly established in writing. At any time a sufficient number of qualified persons shall be available for the performance of these functions. Head of the radiation protection and industrial safety shall have direct access to all levels of PM having authority to establish and/or enforce safety procedures.

4.3 In establishing the plant organisation, other factors to be considered shall include :

(i) availability of off-site technical and administrative services and facilities to the PM for discharging its functions;

(ii) the response time for obtaining the above services and facilities from off-site; and

(iii) arrangement for an effective exchange of experience, services and facilities amongst the plants of the RO.

4.4 Certain functions with a bearing on safety may also be performed by qualified persons outside the PM structure. These functions shall be clearly defined in writing. The actual implementation of these functions on site shall be subject to the approval of the PM.

4.5 When special activities are intended or where the initiative may be in the hands of specialists, either within or outside the PM structure, the contents and the operational details of the proposed procedure for these activities shall be carefully reviewed by persons having a broad understanding of all the safety implications and the PM shall have the ultimate responsibility and authority on performing the proposed activity. Specialists may attend as advisors during the special activity, but no overriding authority shall be vested in them.

4.6 All activities that may affect safety and which can be planned in advance shall be conducted in accordance with established procedures, which shall be submitted by the PM to AERB for approval, if so required by AERB.

4.7 Certain construction activities provide experience for future maintenance and inspection activities. Therefore, PM should arrange for the involvement of its maintenance personnel in construction activities.

4.8 The PM shall arrange for direct involvement of its operating personnel in commissioning such as participation in test preparation, performance of test and evaluation of test results. This enables them to validate the operating procedures and, at the same time, obtain operating experience necessary to facilitate the transfer of responsibilities from the commissioning to the operating group.

4.9 The PM is responsible for the qualification of plant staff and shall support the training organisation with the necessary resources and facilities.

4.10 The PM shall ensure that the plant and site emergency organisation are in a state of readiness to handle the emergency situations.

4.11 The PM shall inculcate safety culture in plant personnel. A policy which gives safety the utmost priority at the plant, overriding the demands of production and plant schedules shall be developed and adhered to by all plant personnel.

4.12 An appropriate system of liaison shall be established by the PM with public authorities and AERB.

4.13 The PM shall submit or make available documents and information in accordance with the requirements of AERB.

4.14 The PM shall develop and effect a procedure for reporting abnormal events to AERB in accordance with established reporting criteria.

4.15 To enable AERB to perform its functions, the PM shall render all necessary assistance and shall grant access to the plant and documents. When so required by AERB, the PM shall undertake special analyses, tests and inspections. The PM, in view of its responsibility for safety, shall make its opinion known to AERB as a basis for subsequent discussions, if it considers that any action to be taken by it as requested by AERB could have an adverse effect on safety.

4.16 The PM shall meet all the requirements of the code on quality assurance for safety in NPP and shall prepare and put in place a comprehensive quality assurance programme covering all activities, which may affect the safe operation of the plant

4.17 The PM shall also have arrangements to use the operational safety experience feedback for implementation of preventive/corrective actions and for identification of good practices.

4.18 The PM shall have arrangement for life management to achieve safe operation throughout the plant life, conforming to regulatory requirements.

4.19 The PM shall arrange for maintenance of proper exclusion boundary.

4.20 The PM shall establish a radioactive waste management programme to ensure that all radioactive waste arising from the operation of the NPP are safely handled, to comply with the requirements of Government Statutory Rules (GSR-125), Atomic Energy (Radiation Protection) Rules, 2004 in force and AERB safety code on 'Management of Radioactive Waste' (AERB/NRF/SC/RW).

5. OPERATING PERSONNEL

5.1 Selection, Training, Qualification and Licensing of Personnel

5.1.1 The RO shall define the necessary qualifications, training and experience required for personnel performing duties that may affect safety. The document containing these requirements shall be issued by RO after obtaining necessary approvals from AERB. Suitably qualified personnel shall be selected and given the necessary training to enable them to perform their duties correctly.

5.1.2 The training programme shall include the following:

(i) selection, training, qualification and retraining to meet commissioning and operational requirements;

(ii) training facilities, curricula, review and updating;

(iii) procedures for qualification and, as applicable, licensing of operating personnel;

(iv) adequate training of selected plant personnel for fire prevention and fire fighting.

(v) adequate training in radiation protection procedures and radiation emergency preparedness;

(vi) training plans to meet decommissioning requirements at the appropriate time; and

(vii) appropriate training in nuclear security of the plant.

5.1.3 The operating personnel whose duties may affect safety shall be medically examined on appointment and prior to certifying to assume the designated posts and also at intervals subsequently as required to ensure their fitness for the duties and responsibilities assigned to them.

5.1.4 Training shall be oriented to develop safety consciousness and safety culture at all levels of the plant organisation structure.

5.1.5 The training[1] shall be imparted to the selected personnel to enable them to perform their duties correctly for the different operational states of the plant and in the event of an accident, in accordance with the appropriate operating or emergency procedures. The training shall cover both theoretical and practical aspects[2], as appropriate, to each category and discipline.

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[1]The training of operating personnel should include familiarity with the symptoms of beyond the design basis accidents and their management.

[2]Advantage should be taken of the commissioning activities to provide additional training and first hand experience for the plant personnel.

5.1.6 Performance based programmes[3] for initial and continuing training shall be developed and put in place for each major group of personnel.

5.1.7 Simulator facilities shall be used for the training of operating personnel for imparting initial and continuing training. Applicable plant modifications shall be incorporated in the simulator.

5.1.8 The PM shall ensure that all personnel who may be required to perform safety related duties have acquired sufficient understanding of the plant and its safety features, and other relevant competencies, such as managerial and supervisory skills, to perform their duties properly with due attention to safety.

5.1.9 A programme shall be put in place to ensure that operating experience of events at the plant concerned as well as of relevant events at other plants is appropriately factored into the training programme. The programme shall ensure that training is conducted on the root cause(s) of the events and on the identification and implementation of corrective action, to prevent their recurrence.

5.1.10 Certain functions are such that responses to situations have to be rapid, consequences of errors in response could be major and verification of response plan before implementation is not feasible. Persons performing these functions shall be required to hold a certification.

5.1.11 The authorised persons shall be covered by periodic retraining programme including the simulator retraining to maintain knowledge proficiency in coping with anticipated operational occurrences and accident conditions and, to minimise human errors.

5.1.12 Personnel certification requirements for normal operation shall be met before commencement of operation.

5.1.13 Persons who have been absent from the certified positions continuously for more than specified periods shall be re-certified based on the established procedures before assuming the certified positions.

5.1.14 Staff certified for other units or similar units shall be re-certified as per established procedures before they are allowed to assume certified positions in the new unit.

5.1.15 Records of the experience, training, qualification and licensing of each member of the operating personnel be maintained by the PM and shall be made available to AERB.

[3]The content of each programme should be based on a systematic approach.

5.1.16 All persons, including security and temporarily employed persons, in the NPP shall be trained to the extent necessary in radiological protection, emergency preparedness, industrial and fire safety and access control.

5.2 Organisational Aspects

5.2.1 Administrative procedure shall lay down functional responsibility, authority, communication channels and inter-relationships of operating personnel at various levels for all operational states, accident conditions and emergency situations.

5.2.2 Only designated and certified operating personnel shall be permitted to control and supervise any changes in the operational states of the plant. Persons holding certified positions shall be instructed to ensure compliance with technical specifications at all times including during tests, experiments and other non-routine operations. Should the need arise they shall have the authority to take the required corrective action including shutting down of the unit to bring the plant back into safe situation. After attaining a safe state of the unit, the status shall be informed to the PM for further actions.

5.2.3 Except as explicitly required by established procedures, the operating personnel shall not alter the configuration of the plant including defeating of interlocks, and installing jumpers, without written approvals by designated persons.

5.2.4 It is considered to be good operating practice to make use of written orders for the purpose of controlling vital operations as appropriate. The use of such written order shall be clearly laid down as a requirement by the PM.

5.2.5 Attitude towards safety shall be a criterion for selecting personnel to occupy senior positions.

6. COMMISSIONING PROGRAMME

6.1 The commissioning programme shall assure that after construction, the NPP is made operational in a safe, systematic, and informative manner. The programme shall verify that the performance criteria, design intent and QA requirements are satisfied. It shall verify and validate the procedures for operating/maintenance/ISI/surveillance etc. to the extent practicable. It shall demonstrate that the plant can be operated in a safe manner.

6.2 The commissioning programme shall include:

(i) organisation structure for the commissioning group with well defined responsibilities;

(ii) interface arrangements among design, construction, commissioning, operating, and regulatory groups;

(iii) test sequence diagrams taking account of intra-system and inter system interfaces;

(iv) stage-wise review requirements and review level (by PM, RO and AERB) and hold points;

(v) procedure to deal with unexpected test results, unusual occurrences and events;

(vi) documentation, reporting of commissioning results and retention of records; and

(vii) provisions to assure preparedness of PM for its responsibilities in the operating phase.

6.3 The commissioning programme shall meet all safety objectives and shall enable review by AERB.

6.4 From commissioning to full power operation, the stages requiring authorisation from AERB, for a given type of reactor, shall be clearly established with the concurrence of AERB. The activities related to these shall be carried out only after obtaining clearance from AERB.

6.5 A sufficient number of qualified operating personnel at various levels and in all areas shall be directly involved in the commissioning process.

6.6 When commissioning activities are conducted under the responsibilities of the supplier or other groups, the PM shall make necessary arrangements to review and approve these activities at all stages.

6.7 All commissioning tests for various stages shall be performed in accordance with approved written procedures, which take into account QA requirements. Comprehensive test reports shall be issued.

6.8 No test shall be performed which could put the plant into conditions that have not been analysed.

6.9 Commissioning programme shall ensure that the baseline data for items important to safety are collected, reviewed for safety in plant operation and retained for subsequent safety reviews.

6.10 All changes to design, programmes, tests, procedures and operational limits and conditions (OLCs) in the course of commissioning shall be carried out as per established procedures.

7. PLANT OPERATIONS

7.1 Technical Specifications for Operation

7.1.1 The operational limits and conditions (OLCs) shall have the purposes of:

(i) prevention of situations which could lead to accident; and

(ii) mitigation of the consequences of any such accident, if it occurs.

7.1.2. OLCs shall be developed covering technical and administrative aspects to ensure that the NPP is operated in accordance with the design assumptions and intent. OLCs shall cover actions to be taken and the limits to be observed by the operating personnel. OLCs shall reflect the provisions made in the final design and shall be related to the results of safety analysis. OLCs shall include requirements for different operational states, including shutdown and startup.

7.1.3 Technical Specifications for operation containing the OLCs and basis of each OLC shall be submitted by PM to AERB for assessment and approval before the commencement of NPP operation. This shall form an important part of the basis on which the PM is authorised to operate the plant.

7.1.4 Approved 'Technical Specifications for Operation' shall be readily accessible to control room personnel. Operating personnel directly responsible for the conduct of operation shall be thoroughly familiar with the intent and content of the operational limits and conditions along with their base in order to comply with the provisions contained therein.

7.1.5 The OLCs are classified as:

(i) safety limits;

(i) limiting safety system settings;

(ii) limiting condition for operation; and

(iii) surveillance requirements.

7.1.6 If a safety limit is violated, the plant shall be brought to the cold shutdown state and no further action shall be taken to make any changes in the configuration of the core, making the reactor critical, pressurise, or heat up the reactor coolant without approval of AERB.

7.1.7 PM may adjust limiting safety systems settings consistent with the operating plans, but such changes shall be on conservative side to benefit from the defense-in-depth concept adopted in design.

7.1.8 Limiting conditions for operation shall ensure

(i) safe operation and avoid reaching the limiting safety system settings, and

(ii) readiness to perform necessary functions in the event of anticipated operational occurrence.

7.1.9 The PM shall ensure that an appropriate surveillance programme is established and implemented to ensure compliance with the operational limits and conditions. The PM shall conduct audits and retain records to assure satisfactory compliance and review of the surveillance.

7.1.10 There shall be separate section in technical specifications/ operational limits and conditions for long shutdown and also another section for en-masse coolant channel replacement (EMCCR) in case of PHWR approved by AERB in addition to those for normal operation and operational states.

7.1.11 The OLCs shall be reviewed based on the results of commissioning tests, operating experience and new relevant information. If considered appropriate, they may be modified after approval by AERB.

7.1.12 Violation of any of the OLCs shall be notified to AERB or its designated body as per the established event reporting system by the PM. Consequent action specified by AERB, if any, shall be implemented in a timely manner.

7.2 Operating Instructions and Procedures

7.2.1 A comprehensive administrative procedure shall be established for document control including operating instructions and procedures as per code of practice on Quality Assurance for Safety in Nuclear Power Plants (AERB/SC/QA).

7.2.2 Operating instructions and procedures[4] are required to be established to operate, maintain and manage the NPP in a planned, systematic and safe manner in order to assure:

(i) that all activities affecting safe operation have appropriate instructions or procedures;

(ii) compliance with OLCs and other regulatory requirements;

(iii) consistency with the design intent; and

(iv) management of the plant under abnormal conditions.

[4]The use of symptom oriented procedures for dealing with anticipated operational occurrences and for the management of accident conditions is recommended as far as practicable, taking into account all the capabilities of the plant which are available under the respective conditions. Procedures should be written so that each action can be readily performed in a proper sequence by the designated responsible person. There should be proper integration of design provisions, emergency operating procedures, accident management and emergency preparedness plans.

7.2.3 The operating procedures shall be written and verified by competent persons before approval by designated authority. These procedures shall have detailed instructions for qualified personnel to perform the specified tasks without direct supervision. The procedures shall include sections dealing with plant under normal operation and anticipated operational occurrences as well as appropriate actions for accident conditions including design basis accidents. Emergency operating procedures or guidance shall be developed for managing severe accidents.

7.2.4 The PM shall ensure that detailed operating instructions and procedures are set out in writing and be available for training and qualification of operating personnel before the commencement of operation. Every instruction and procedure shall be carefully evaluated to assess its significance to safety. They shall comply, with reasonable margins on the safe side; with the established OLCs. The above provisions also apply to any subsequent modification of such instructions and procedures. The PM shall ensure that these instructions and procedures are carefully followed in operating the plant.

7.2.5 Responsibilities and lines of communication shall clearly be set out in writing for those situations in which the operating personnel are forced to deviate from written procedures. No other person shall interfere in their decisions relevant to safety.

7.2.6 Special procedures/tests, which could result in the deviation from approved OLCs shall be carried out only with the prior approval of AERB or its designated agency. During execution of these procedure/test, the overriding authority of the persons who manipulate the reactor controls and who supervise such operation to terminate the procedure and to bring the plant to a safe state shall not be jeopardised.

7.2.7 Adequate arrangements shall be made for the periodic review and revision, if necessary, of all instructions and procedures within a specified period of time in accordance with written procedures.

7.3 Core Management and Fuel Handling

7.3.1 The core management shall be such as to ensure safety of the reactor fuel and core components in all operational states with required safety margin. The RO shall ensure that satisfactory administrative arrangements are made for the core management activities and that close liaison amongst the design group and PM is established and maintained, considering the restraints imposed by the fuel and plant design limitations as well as the dynamic core conditions during operation.

7.3.2 PM shall be responsible and shall make arrangements for all the activities associated with core management and on-site fuel handling in order to ensure the safe use of the fuel in the reactor and safety in its movement and storage

on the site. Provisions shall be made to ensure that only fuel whose design and enrichment have been approved by AERB for use in a particular reactor is loaded in that reactor.

7.3.3 A fuelling programme shall be established in accordance with the design intent and assumptions and shall be submitted to AERB.

7.3.4 PM shall have approved procedures for the loading, utilisation, unloading and testing of fuel and core components.

7.3.5 For NPPs where on-load refueling is adopted, the procedures shall ensure that the reactivity changes during refueling are within the capabilities of regulating system and in conformance with the stipulations in the technical specification for operation.

For NPPs where off-line batch refueling is adopted, tests shall be performed before and during startup to confirm that requirements regarding shutdown capability of reactor are met and the core performance meets the design intent.

7.3.6 Core conditions shall be monitored during and after the refueling and the fuelling programme shall be reviewed and modified as necessary.

7.3.7 Criteria shall be established and procedures shall be written for identification and handling of failed fuel or core components.

7.3.8 For fuel and core components, handling procedures shall be written which include the movement of un-irradiated and irradiated fuel, storage on the site and shipment from the site. The plans for storage of the un-irradiated and irradiated fuel shall ensure that fuel integrity and sub-criticality are maintained, and the plans shall be submitted to AERB for approval.

7.3.9 The packaging, carriage and dispatching of un-irradiated and irradiated fuel and blanket material, where applicable shall be carried out in accordance with relevant regulatory requirements.

7.3.10 Detailed auditable accounts shall be maintained for the storage, irradiation and movement of all fissile material, including un-irradiated and irradiated fuel.

8. MAINTENANCE, TESTING, SURVEILLANCE AND INSPECTION

8.1 At the design stage, the RO shall arrange a review by experienced operating personnel to ensure proper operability covering areas such as human factors, maintainability, inspectability and testability of structures, systems and components (SSCs) of NPP.

8.2 Before commencement of operation, the PM shall prepare a programme of periodic maintenance, testing, surveillance and inspection of items important to safety (IIS). This programme shall take into account operational limits and conditions as well as any other applicable regulatory requirements. It shall be available to AERB and re-evaluated in the light of operating experience.

8.3 The programme shall include periodic inspections or tests of systems, structures and components important to safety in order to demonstrate their reliability and to determine whether they are acceptable for continued safe operation of the plant or whether any remedial measures are necessary.

8.4 The PM shall arrange for satisfactory periodic tests, examinations and inspections to be carried out by qualified persons using appropriate equipment and techniques.

8.5 The maintenance, testing, surveillance and inspection of all IIS shall be of such standard and frequency as to ensure that their level of reliability and effectiveness remains in accordance with the design assumptions and intent, and that the safety status of the NPP has not been adversely affected since the commencement of operation.

8.6 The PM shall ensure that instructions and procedures are set out in writing before maintaining, testing, examining or inspecting items. The documents shall include provisions for keeping exposure of site personnel as low as is reasonably achievable. The procedures as well as any subsequent modifications, shall be prepared, reviewed and issued in accordance with the provisions of the QA programme.

8.7 The frequency of preventive and predictive maintenance, testing, surveillance and inspection of individual structures, systems and components shall be determined on the basis of:

(i) the importance to safety of the structures, systems and components;

(ii) their inherent reliability;

(iii) their assessed potential for degradation in operation and their ageing characteristics;

(iv) operating experience; and.

(v) periodic safety review.

8.8 A comprehensive work planning and control system shall be implemented to ensure that maintenance, testing, surveillance and inspection work is properly authorised and is carried out in accordance with established procedures. The PM shall ensure the effective performance and control of maintenance activities during planned and forced outages.

8.9 The work control system shall ensure that concerned SSCs and the plant is released from service for maintenance, testing, surveillance or inspection only with the authorisation of designated operations staff after the due safety assessment and in compliance with the operational limits and conditions. It shall also ensure that, following maintenance, the plant is not returned to service before completion of a documented check of its configuration and, where appropriate, a functional test. This will ensure non availability of safety equipment/system does not remain latent.'

8.10 Following any abnormal event, the PM shall revalidate the safety functions and functional integrity of any component or system, which may have been challenged by the event. Necessary remedial actions shall include inspection, testing and maintenance as appropriate.

8.11 Data on maintenance, testing, surveillance, inspection and reliability shall be recorded, stored and analysed to confirm that performance is in accordance with design assumptions and with expectations on equipment reliability.

8.12 The PM shall establish a programme of surveillance, review and audit of maintenance activities.

8.13 The in-service inspection programme shall be established prior to commencement of operation to examine items for possible deterioration.

8.14 A pre-service examination of all systems and components selected for in-service inspection shall be done before the commencement of operation to provide baseline data. Baseline data shall also be collected for a component when it is repaired or replaced.

8.15 Inspection methods, techniques and procedures shall be formulated in accordance with applicable codes and standards acceptable to AERB.

8.16 The results of in-service inspection shall be evaluated for compliance with the requirements of the applicable codes and standards.

9. OPERATIONAL SAFETY EXPERIENCE FEEDBACK

9.1 Operating experience at the plant shall be evaluated in a systematic way. Events with significant safety implications shall be investigated to establish the direct and root causes. The investigation shall, where appropriate, result in clear recommendations to the PM, which shall take appropriate and timely corrective action. Information resulting from such evaluations and investigations shall be fed back to the plant personnel.

9.2 PM/RO[5] shall establish a programme for the collection and analysis of operational safety experience feedback (OSEF) including those from other plants in India and abroad to arrive at corrective actions and to monitor any adverse trend in the plant safety performance.

9.3 All plant personnel shall be required to report all events including low level events and shall be encouraged to report on any near misses[6] relevant to safety of the plant to PM. PM shall investigate and take appropriate and timely corrective actions.

9.4 PM/RO shall maintain liaison as appropriate with the organisations (manufacturer, research organisation, designer) involved in the design and manufacturing with the aim of sharing the information on operating experience and obtaining advice, if necessary, in the event of equipment failures or abnormal occurrences.

9.5 Data on operating experience shall be collected and retained for use as input for the management of plant ageing, for the evaluation of residual plant life, for probabilistic safety assessment and periodic safety review.

9.6 PM shall be responsible for disseminating the OSEF to plant personnel through appropriate means including training.

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[5]The RO/PM should have a system of sharing operational safety experience nationally and internationally

[6]The term *near miss* is used for a potentially significant event that could have occurred as the consequence of a sequence of actual occurrences but did not occur owing to the plant conditions prevailing at that time. Further, there should be a system of reviewing of events, drawing lessons and feedback implementation, corrective actions and documentation of all these.

10. PLANT MODIFICATIONS

10.1 Modifications during operation of the NPP may consist of:

(i) modifications to structures, systems and components (SSCs);

(ii) modifications to operational limits and conditions;

(iii) modifications to the operation/maintenance/surveillance/test procedures;

(iv) modifications of the organisation;

(v) modifications to the software; and

(vi) a combination of the above

10.2 Modifications involving SSCs including software and changes in OLCs shall conform to the provisions set forth in the code of practice on design. In particular the capacity of safely shutting down the reactor under any anticipated operational occurrence or accident condition shall be maintained. The capability of performing all safety functions shall not be degraded. The ultimate prevention of reactivity accidents as well as other design basis accidents shall be by automatic protective devices and shall not be left to the exclusive operator actions.

10.3 Modifications to SSCs including software, which affect the bases on which consent to operate the NPP was issued shall be reviewed and cleared by the designer. These modifications and resultant changes to the OLCs shall be submitted to AERB for prior approval.

10.4 Modifications relating to the organisational aspects, which are relevant to the safe operation of the plant, shall be submitted to AERB.

10.5 The RO/PM shall establish a procedure to ensure proper design, review, control and implementation of all permanent and temporary modifications. This procedure shall ensure that the requirements of the plant safety analysis report and applicable codes and standards are met.

10.6 All safety related components and systems affected by the modification shall be subject to testing in accordance with the plant's work control system and with appropriate testing procedure before declaring them operational. Additional surveillance shall be carried out during initial run to ensure safe operation of the affected components and systems.

10.7 Temporary modifications (including defeat of interlocks, installation of jumpers) shall be clearly identified at the point of application and at the main control room. Operating personnel shall be clearly informed of these temporary modifications and of their consequences under all operating conditions. PM

shall ensure that the temporary modifications are periodically reviewed and normalised as early as possible.

10.8 As a part of configuration management PM shall ensure that plant modifications are brought into routine operation after updating the relevant instructions, drawings, cable routes, component lists, maintenance manual, procedures, work instructions, other relevant documentation particularly the documents for shift operators and the training programme.

11. RADIATION PROTECTION

11.1 A radiation protection programme (RPP) shall be established by the PM prior to the commencement of operation of the NPP to ensure protection of site personnel, members of the public and the environment from adverse effects of ionising radiation.

11.2 The RPP shall be established on the basis of general principles of radiation protection and shall meet the requirements laid down by AERB based on Atomic Energy (Radiation Protection) Rules, 2004. Plant specific Radiation protection procedure/manual shall be prepared by PM and get it approved by AERB prior to start of commissioning

11.3 A health physics unit shall be established at the NPP prior to commencement of operation to ensure that the RPP is implemented.

11.4 The RPP shall be based on a prior assessment of radiological conditions of the plant and shall cover:

(i) organisational structure of the health physics unit at the NPP,

(ii) area/zone classification of plant areas and access control ,

(iii) exposure control scheme and work procedures,

(iv) area radiation monitoring and surveys,

(v) environmental radiological surveillance and monitoring,

(vi) determination of external and internal doses,

(vii) decontamination procedures and methods ,

(viii) control, handling, storage and transport of radioactive materials including radioactive wastes,

(ix) control and monitoring of radioactive liquid and gaseous releases,

(x) instrumentation and equipment for monitoring,

(xi) equipment for personnel protection,

(xii) training/retraining of personnel including temporary workers in radiation protection and emergency procedures,

(xiii) health surveillance of radiation workers,

(xiv) documentation of data on radiological conditions of the plant, personnel exposures and effluent discharges ,

(xv) training and qualification of health physics personnel, and

(xvi) QA programme.

11.5 Adequate number of health physicists shall be located at the site to ensure effective implementation of the radiation protection programme. The station health physicist shall have direct access to all levels of PM having authority to establish and/or enforce safety procedures.

11.6 The health physics unit shall be responsible for auditing compliance with the requirements of this programme by the site personnel and sending periodic reports to the PM and AERB.

11.7 Exposures of all site personnel working in a controlled area or regularly employed in a supervised area shall be monitored by appropriate means. The dose records shall be maintained as specified and made available to AERB.

11.8 A health surveillance programme for radiation workers, based on general principles of occupational health shall be established and maintained to assess the initial and continuing fitness for their intended tasks and to provide a baseline data and also to give advice in case of accidental exposure. The health surveillance programme shall consist of pre-employment and periodic medical examinations.

11.9 Radiation exposure records of all site personnel shall be maintained at the site. Other records, which shall be maintained at the site, include:

(i) movement and storage of radioactive materials;

(ii) activity measurements;

(iii) radiation fields in the controlled and the other areas;

(iv) radioactive wastes disposed;

(v) results of environmental monitoring;

(vi) radiation qualification status of plant personnel for working in radiation areas;

(vii) medical examination schedule and results for site personnel occupationally exposed to radiation; and

(viii) reports of cases of exposures above investigation level.

12. NUCLEAR SECURITY

12.1 The security arrangements relevant to nuclear material and safe operation of the NPP shall be established before the commencement of operation.

12.2 The security system established at site shall cater to:

(i) prevention or deterring unauthorised entry of persons, vehicle and material;

(ii) prevention of unauthorised transfer of nuclear material and/or sabotage of plant;

(iii) enabling timely detection of unauthorised entries and apprehension of unauthorised persons; and

(iv) neutralise adversaries acting in a manner constituting a security threat.

12.3 The RO shall arrange, at the design stage for:

(i) security provisions in the plant design and layout including restrictions on number of openings for entry into the buildings;

(ii) identification of vital areas of the NPP and to meet the requirements for such areas; and

(iii) the design of physical protection system (PPS).

The above shall meet the identified design basis threats (DBTs) by considering review of design provisions, the characteristics of site and adversaries.

12.4 An approved site-specific manual on security prepared in line with 'Manual on Security of Nuclear Power Plants' issued by AERB shall be available at NPP site and shall be adhered to. This document shall be a classified document.

12.5 The PM shall take measures as appropriate to prevent or deter unauthorised access to, intrusion into, theft of, surface attack on, and internal or external sabotage of safety related systems and nuclear materials.

12.6 The PM shall inculcate security culture in plant personnel.

12.7 The PM shall arrange for maintenance of recommended main plant boundary.

12.8 Arrangements shall be made to ensure that status of items of importance to nuclear security including those on standby duty and engineered safety features are monitored through engineered/procedural system. Unexplained variation from expected status shall be treated as potential security breach.

12.9 Mock drill on security shall be conducted periodically.

12.10 Security threats having an immediate bearing on safety or requiring plant shutdown shall be promptly reported to AERB.

12.11 Information on security arrangements shall be disseminated on 'need to know' basis only.

13. EMERGENCY PREPAREDNESS

13.1 An emergency preparedness programme shall be established to provide reasonable assurance that, in the event of an emergency situation, appropriate measures can and will be taken to mitigate the consequences. This programme shall be in force before commencement of operation.

13.2 As a part of the emergency preparedness programme, the PM shall ensure that:

(i) the emergency preparedness plans for NPP be drawn up and approval from appropriate authority obtained;

(ii) necessary training imparted to personnel; and

(iii) the implementability of the action plans confirmed by conducting exercises.

13.3 Emergency situations shall be classified covering the entire spectrum of postulated radiological consequences, so that a graded scale of response consistent with the magnitude of the situation can be specified and ensured.

13.4 The organisation for emergency response shall consist of site and off-site personnel/groups including public authorities who have a role to play during off-site emergency. The on-site organisation, under the guidance of a site emergency director, shall be responsible for its assigned functions and safety of the site personnel. The off-site organisation shall normally have its base at a convenient off-site location and it shall be activated in the case of off-site emergency situations. In such a case the off-site emergency director is responsible for directing both site and off-site actions; site emergency director shall assist the off-site emergency director in accordance with the plan.

13.5 The emergency preparedness plan shall include the following:

(i) the designations of persons for directing on-site activities and for ensuring liaison with off-site organisations;

(ii) the conditions, under which an emergency shall be declared, a list of job titles and/ or functions of persons empowered to declare it and a description of suitable means for alerting response personnel and public authorities;

(iii) the arrangement for initial and subsequent assessment of radiological conditions on and off the site;

(iv) provisions for minimising the exposure of persons to radiations and for ensuring medical treatment to affected persons as applicable;

(v) assessment of the state of the installation and the actions to be taken on the site to limit the extent of radioactive release;

(vi) the chain of command and communication, including description of related facilities and procedures;

(vii) an inventory of the emergency equipment to be kept in readiness at specified locations;

(viii) the actions to be taken by persons and organisations involved in the implementation of the plan; and

(ix) provision for declaring the start and termination of an emergency.

13.6 The emergency plan shall also include arrangements for emergencies involving a combination of non-nuclear and nuclear hazards, such as a fire in conjunction with significant levels of radiation or contamination, or toxic or asphyxiating gases in conjunction with radiation and contamination, with account taken of the specific site conditions.

13.7 Instruments, tools, equipment, documentation and communication systems to be used in emergencies shall be kept available and shall be maintained in good operating condition in such a manner that they are unlikely to be affected by or made unavailable by the postulated accidents.

13.8 When an emergency situation is suspected, action shall be taken immediately to correct the abnormal condition. On identification of situation, the emergency measures begin with the declaration of emergency and prompt activation of the associated response organisations. The other emergency measures shall include:

(i) notification of emergency through pre-established codes, procedure and communication channels;

(ii) assessment of the emergency situation on a continuing basis and modification of emergency measures as appropriate;

(iii) actions to correct or mitigate the situation at or near the source of the problem including fire control, first aid, rescue and damage control;

(iv) protection of the personnel and, protective measures to be implemented at the site and those to be taken by public authorities in a mutually complimentary manner; and

(v) collection of data including plant, radiological and meteorological parameters from existing instrumentation, on-site and environmental radiological surveys, data analysis, eyewitness accounts and results of actions taken.

13.9 Site emergencies shall be terminated when the site emergency director is satisfied that the emergency situation no longer exists, the plant is under control and the effluent releases are within acceptable limits. Off-site emergency shall be terminated only when the emergency director is satisfied that, in

addition to the above conditions, all necessary protective measures have been taken and are continuing to be taken to protect the public and environment from contamination and to minimise exposures.

13.10 The requirements to be met for maintaining a high degree of emergency preparedness shall include:

(i) training and periodical retraining of all site personnel in emergency procedures, site and off site personnel designated for specific duties and actions during emergency and first aid and medical personnel in handling patients who are contaminated or over exposed to radiation,

(ii) display of emergency instructions at all assembly areas and vantage points,

(iii) periodic inventory, surveillance and maintenance of all emergency equipment and supplies to ensure their operational readiness,

(iv) periodic exercises of all types of emergency situations with particular stress on checking all communication channels, determining the time required for various actions, and effective co-ordination between on-site groups and off-site groups/ organisations with designated key personnel and their alternates assuming responsibility,

(v) periodic review, updating and improving of emergency plans and procedures in the light of actual experience and results of exercises and communication of such revisions to all groups within the PM and public authorities, and

(vi) review and updating of emergency plans and procedures to take care of changes at site including construction of new facilities.

13.11 The plan for site-specific emergencies such as those arising from natural disaster for example tsunami, cyclone, etc. shall be drawn up before commencement of plant operation.

14. RENEWAL OF AUTHORISATION

14.1 The PM shall seek renewal of authorisation for operation from AERB before the expiry of the authorised period of operation.

14.2 Application for renewal of authorisation shall be accompanied by systematic safety assessments i.e. periodic safety review (PSR) of the plant in accordance with the regulatory requirements.

14.3 The strategy and scope for the review and the safety factors to be evaluated during periodic safety review (PSR) shall be agreed to by AERB.

14.4 During PSR, it shall be determined to what extent the existing safety analysis reports remain valid. The PSR shall take into account the actual status of the plant, effectiveness of management, operating experience both internal and external, equipment qualification, management of ageing, reliability of safety systems, availability of trained manpower, current analytical methods, applicable safety standards and the state of knowledge. The PSR shall also include on-site and off-site emergency planning, accident management and radiation protection aspects.

14.5 In order to complement the deterministic assessment, consideration shall be given to the use of probabilistic safety assessment (PSA) as an input to the PSR to provide insight into the relative contributions to safety of various aspects of the plant.

14.6 The PM shall implement any necessary corrective actions resulting from PSR based on safety significance.

14.7 In between two PSRs, as per items 14.4 and 14.5 above, safety assessments of limited scope shall be carried out as per the guidelines of regulatory body before submission of application for renewal of authorisation.

15. RECORDS AND REPORTS

15.1 The PM shall make arrangement for management of records and reports as required by the safety code on 'Quality Assurance for Safety in Nuclear Power Plants' (AERB/SC/QA).

15.2 Arrangements for operational records and reports shall provide for

(i) categorisation of permanent and non-permanent records,

(ii) stipulation of retention period with account taken of regulatory requirements,

(iii) procedures for updating of records or addition of supplements,

(iv) receipt control including completeness reviews,

(v) retrieval, accessibility and disposal arrangements,

(vi) suitability of storage arrangements,

(vii) requirements for record duplication and its storage in separate location,

(viii) record preservation, and

(ix) periodic review.

15.3 The management of records shall include records in respect of:

(i) design specifications;

(ii) safety analyses;

(iii) equipment and material supplied;

(ii) as-built installation drawings;

(iii) manufacturers' documentation;

(i) commissioning documents;

(ii) plant operational data;

(iii) events;

(iv) amounts and movements of fissile, fertile, radioactive and other special materials;

(v) data of maintenance, testing, surveillance, inspection and reliability;

(vi) history of, and data on modifications;

(vii) quality assurance;

(viii) qualifications, positions, medical examinations and training of site personnel;

(ix) plant chemistry;

(x) occupational exposure;

(xi) radiation surveys;

(xii) discharges of effluents;

(xiii) environmental monitoring;

(xiv) storage and transport of radioactive waste;

(xv) periodic safety reviews;

(xvi) decommissioning documents.

15.4 The document management system shall be such as to ensure that only the latest version of each document is used by personnel.

15.5 Reports and records relevant to significant events/accidents, the reviews carried out following them and the reports on modification shall be kept as required and shall be available to AERB as and when required.

16. PLANT LIFE MANAGEMENT

16.1 Structures, systems, and component (SSCs) of NPP are likely to experience degradation caused by various factors such as ageing, environment, or combinations thereof etc. thus having a potential for reducing the safety margins originally provided in the design unless appropriate timely actions are taken.

16.2 A programme[7] for life management shall be instituted so as to ensure that items important to safety of the NPP function without impairment of their reliability and intended safety margins.

16.3 RO/PM shall have appropriate organisational set up to develop and implement life management programme.

16.4 Considerations in formulating the life management programme should include:

(i) degradation of plant SSC caused by a combination of ageing mechanisms, and premature degradation during various phases of plant life,

(ii) understanding the role of service environment and various degradation mechanisms in causing premature ageing and implementing suitable O & M practices for minimizing degradation, and

(iii) up-gradation of safety levels to the extent feasible with increase in knowledge (including change in regulatory requirements, if any) and improvement in technology.

16.5 Life management programme and the activities thereof shall be reviewed periodically by RO/PM and the results of the review shall be submitted to AERB. If the safety level falls below the original design intent, safety level or external hazard perception changes for the worse, AERB may withdraw the license to operate and the plant shall be shut down.

16.6 If RO/PM desires extension of operation beyond design life, it shall apply for license renewal well before the end of the design life of an NPP. Acceptance criteria for life extension shall be as per guidelines issued by AERB.

The key issues to be considered for life extension are:

(i) compliance with the current safety principles and practices,

[7]This programme should be conceived and implemented from site selection through the entire life of NPP.

(ii) safety goals, as in original design, or higher due to various improvements implemented,

(iii) adequacy of residual life of SSCs important to safety,

(iv) identification of systems requiring up-gradation, and

(v) safety culture.

17. PROBABILISTIC SAFETY ASSESSMENT

17.1 Probabilistic safety assessment (PSA) provides a comprehensive, structured approach to identifying accident scenarios and deriving numerical risks. Level 1 PSA identifies the event sequences leading to core damage and estimates the core damage frequency. Level 2 PSA identifies the radioactivity release pathways from the plant and estimates their magnitude and frequency. Level 3 PSA identifies the exposure pathways to the public and estimates the public health effects and other societal risks.

17.2 As a minimum requirement, internal event plant-specific Level 1 PSA[8] (full power) shall be performed for all NPPs. For new NPPs, it shall be completed prior to first criticality and for NPPs in operation, it shall be updated and presented as a part of PSR.

17.3 The PSA shall be kept up-to-date during the plant lifetime taking into account design modifications, changes in operational practices and updated statistical data on initiating event frequencies and component reliability data obtained during the plant operation.

[8]It is desirable that PSA at all three levels should be performed considering internal as well as external events. Considerations should be given to the use of Level 1 PSA results for developing risk-based safety performance indicators, configuration control programme, technical specifications changes etc. Considerations can also be given to the use of Level 2 PSA results for the development of the severe accident management guidelines and operator training for the emergency conditions. The Level 3 PSA results may be used for assessing the effectiveness of various protective measures as a part of emergency planning.

18. DECOMMISSIONING

18.1 Feasibility of safe decommissioning and subsequent site remediation of NPP shall be considered during site selection, design and construction stages of consenting process and conceptual decommissioning plan shall be submitted to AERB as a part of safety analysis report.

18.2 The conceptual plan of decommissioning shall be periodically updated based on operational experience and changes incorporated in plant configuration. At the end of plant design life, five years before expiry of operating license, the RO shall carry out a complete review on the basis of which it may seek from AERB an extension of the operating licence beyond the design life or submit an application for decommissioning and dismantling.

18.3 In case a decision is taken to terminate the operation of a NPP permanently, before end of its design life it shall be brought to a guaranteed shutdown state but the decommissioning shall be started only after the approval of AERB.

18.4 The PM shall keep in mind the aspects of decommissioning and dismantling[9] during operational life of the plant.

[9]Experience in handling contaminated or irradiated items during maintenance or modification (or during EMCCR in PHWR) of the NPP should be recorded in order to facilitate the planning.

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LIST OF PARTICIPANTS

COMMITTEE FOR REVISION OF AERB CODE OF PRACTICE ON SAFETY IN NUCLEAR POWER PLANT OPERATION (CRACSNO)

Dates of meeting	:	November 25, 2005 January 19, 2006 March 30 & 31, 2006 April 27 & 28, 2006 May 15 & 16, 2006 May 29, 2006

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Shri S.K. Agarwal	:	BARC
Shri U.S. Khare	:	NPCIL
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ADVISORY COMMITTEE ON CODES, GUIDES AND ASSOCIATED MANUALS FOR SAFETY IN OPERATION OF NUCLEAR POWER PLANTS (ACCGASO)

Dates of meeting	:	October 24, 2005 July 20 & 21, 2006 November 16, 2006

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ADVISORY COMMITTEE ON NUCLEAR SAFETY

Dates of meeting	:	December 17, 18, 19 & 20, 2007

Members of ACNS:

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PROVISIONAL LIST OF SAFETY CODE, GUIDES, MANUALS, AND TECHNICAL DOCUMENTS ON NUCLEAR POWER PLANT OPERATION

Safety Series No.	Titles
AERB/NPP/SC/O	Nuclear Power Plant Operation
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AERB/SG/O-2	In-Service-Inspection of Nuclear Power Plants
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AERB/SG/O-6	Preparedness of the Operating Organisation for Handling Emergencies at Nuclear Power Plants
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AERB/SG/O-9	Management of Nuclear Power Plants for Safe Operation
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AERB/SG/O-10B	Core Management and Fuel Handling in Operation of Boiling Water Reactors
AERB/SG/O-11	Management of Radioactive Waste Arising from Operation of Pressurised Heavy Water Reactor Based Nuclear Power Plants
AERB/SG/O-12	Renewal of Authorisation for Operation of Nuclear Power Plants
AERB/SG/O-13	Operational Safety Experience Feedback on Nuclear Power Plants

PROVISIONAL LIST OF SAFETY CODE, GUIDES, MANUALS, AND TECHNICAL DOCUMENTS ON NUCLEAR POWER PLANT OPERATION (CONTD.)

Safety Series No.	Titles
AERB/NPP/SG/O-14	Life Management of Nuclear Power Plants
AERB/NPP/SG/O-15	Proof and Leakage Rate Testing of Reactor Containments
AERB/NPP/SG/O-16	Commissioning of Pressurised Water Reactor Based Nuclear Power Plants
AERB/NF/SM/O-1	Probabilistic Safety Assessment for Nuclear Power Plants and Research Reactors
AERB/NF/SM/O-2 (Rev. 4)	Radiation Protection for Nuclear facilities
AERB/NPP/TD/O-1	Compendium of Standard Generic Reliability Database for Probabilistic Safety Assessment of Nuclear Power Plants.
AERB/NPP/TD/O-2	Human Reliability Analysis: A Compendium of Methods, Data and Event Studies for Nuclear Power Plants

AERB SAFETY CODE NO. AERB/NPP/SC/O (Rev. 1)

Published by: Atomic Energy Regulatory Board,
Niyamak Bhavan, Anushaktinagar.
Mumbai – 400 094