GOVERNMENT OF INDIA

AERB SAFETY GUIDE

PERIODIC SAFETY REVIEW FOR NUCLEAR POWER PLANTS

ATOMIC ENERGY REGULATORY BOARD

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PERIODIC SAFETY REVIEW

FOR

NUCLEAR POWER PLANTS

Atomic Energy Regulatory Board

Mumbai-400094

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Orders for this guide should be addressed to:

Chief Administrative Officer
Atomic Energy Regulatory Board
Niyamak Bhavan
Anushaktinagar
Mumbai-400094
India

FOREWORD

Activities concerning establishment and utilization 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 codes, safety standards 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, the other documents cover regulatory aspects of these facilities.

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

The Safety Code on 'Nuclear Power Plant Operation' (AERB/NPP/SC/O Rev-1, 2008) lays down the requirements for ensuring safety in plant operation. This safety guide is one of the series of guides, under the safety code to describe and elaborate specific parts of the safety code. It provides guidance for conducting periodic safety review of nuclear power plants in India and is intended for their plant management. This revised safety guide supersedes the earlier 2000 edition of AERB/SG/O-12 titled 'Renewal of Authorisation for Operation of Nuclear Power Plants'.

The draft of the guide has been prepared in-house. Experts have reviewed the draft and the Advisory Committee on Nuclear and Radiation Safety vetted it before issue. In drafting this guide, the relevant International Atomic Energy Agency (IAEA) documents under the nuclear safety standards (NUSS) programme, especially IAEA Specific Safety Guide No. SSG-25 (2013) on 'Periodic Safety Review for Nuclear Power Plants' have been referred extensively. References are included to provide information that might be helpful to the user.

The standards mentioned in the safety guide are acceptable to AERB. Equivalent standards other than those mentioned in the safety guide may also be acceptable if they provide at least a comparable assurance of safety intended in the standards mentioned in this safety guide. For aspects not covered in this guide, national and international standards, codes and guides applicable and acceptable to AERB should be followed. Non-radiological aspects of industrial safety and environmental protection are not explicitly considered in this guide. Industrial safety shall be ensured by compliance with the applicable provisions of the Factories Act, 1948 and the Atomic Energy (Factories) Rules, 1996.

AERB acknowledges the efforts of all individuals and organisations who have prepared and reviewed the draft and helped in its finalisation.

(G. Nageswara Rao)
Chairman, AERB

Definitions

Acceptable Limits
Limits acceptable to the regulatory body on the predicted radiological consequences of an accident (or on potential exposure if they occur).

Accident Conditions
Deviations from normal operation which are less frequent and more severe than anticipated operational occurrences, and which include design basis accidents and design extension conditions.

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

Anticipated Operational Occurrence
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[1]
See Licence

Atomic Energy Regulatory Board (AERB)
The 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.

Authorisation[2]
A type of regulatory instrument issued by the regulatory body for:

i. all sources, practices and uses involving radioactive materials and radiation-generating equipment and
ii. disposal or transfer of radioactive waste

Commissioning
The process by means of which systems and components of nuclear and radiation facilities, having been constructed, are made operational and verified to be in accordance with the design intent and to have met the required performance criteria.

[1] The term 'Approval' is also used in regulatory process in the context of 'regulatory acceptance' of dose budget proposal, approval of Technical Specification for Operation, approval of Radiation Safety Officer etc. It is to be distinguish from the term 'Approval' used as a 'regulatory instrument'.
[2] The 'Authorisation', in the form of 'Licence' is issued in conformity with the Atomic Energy (Radiation Protection) Rules, 2004. The 'Authorisation' is also issued in conformity with Atomic Energy (Safe Disposal of Radioactive Waste) Rules, 1987 also.

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

Construction
The process of manufacturing 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.

Decommissioning
The process by which the use of radiation equipment or installation is discontinued on a permanent basis, with or without dismantling the equipment, including removal or containment of radioactive materials.

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.

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.

Licence[3]
A type of Regulatory instrument issued by the regulatory body to perform specified activities relating to particular 'sources' and 'practices' specified in Rule 3 of Atomic Energy (Radiation Protection) Rules, 2004

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

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

[3] The Licence may take other forms, such as 'Authorisation', 'Registration', 'Consent' or 'Approval' in conformity with the Atomic Energy (Radiation Protection) Rules, 2004.
Authorisation is also issued in conformity with Atomic Energy (Safe Disposal of Radioactive Waste) Rules, 1987 also.

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 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 risks.

Operation
All activities following commissioning (after initial fuel loading) performed to achieve, in a safe manner, the purpose for which a nuclear/radiation facility is constructed. For nuclear power plants, this includes maintenance, refueling, in-service inspection and other associated activities performed during initial operation, regular operation or long term operation.

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

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

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 licensed nuclear/radiation facility (see also “Technical Specifications for Operation”).

Operational States
The states defined under “normal operation” and “anticipated operational occurrences”.

Periodic Safety Review
A systematic reassessment of the safety of an existing facility (or activity) carried out at regular intervals to deal with the cumulative effects of ageing, modifications, operating experience, technical developments and siting aspects, and aimed at ensuring a high level of safety throughout the service life of the facility (or activity).

Plant Management
The members of site personnel who have been delegated responsibility and authority by the Operating Organisation for directing the safe operation of the plant.

Prescribed Limits
Limits established or accepted by the regulatory body.

Protection System
System that monitors the operation of a reactor and which, on sensing an abnormal condition, automatically initiates actions to prevent an unsafe or potentially unsafe condition.

Qualified Person
An individual who, by virtue of certification by appropriate boards or societies, professional licence or academic qualifications and experience, is duly recognised as having expertise in a relevant field of specialization, for example medical physics, radiation protection, occupational health, fire safety, quality management or any relevant engineering or safety specialty.

Quality Assurance
The function of a management system that provides confidence that specified requirements will be fulfilled

Records
Documents which furnish objective evidence of the quality of items and activities affecting quality. It also includes logging of events and other measurements.

Regulatory Body
(See “Atomic Energy Regulatory Board”).

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.

Safety
(See “Nuclear Safety”).

Safety Actuation System
A set of equipment required to accomplish the necessary safety actions when initiated by the protection system.

Safety Related Systems
Systems important to safety that are not included in ‘Safety Systems’.

Safety System
System important to safety; provided to ensure during and following anticipated operational occurrences and design basis accident:

- Capability to shut down the reactor and maintain it in safe shutdown state; and/or
- Integrity of the reactor coolant pressure boundary; and/or,
- residual heat removal from the core; and/or
- Containment of radioactivity to limit the consequences.

Safety Support System
Systems which encompass all equipment that provide services, such as cooling, lubrication and energy supply (pneumatic or electric) required by the protection system and safety actuation systems.

Severe Accident
Accident conditions more severe than design basis accident and involving significant core degradation including core melt.

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

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 specified requirements are satisfied.

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 submitted on behalf of or by the responsible organisation covering operational limits and conditions, surveillance and administrative control requirements for the safe operation of the facility and approved by Regulatory Body.

Verification
The act of reviewing, inspecting, testing, checking, auditing, or otherwise determining and documenting whether items, processes, services or documents conform to specified requirements.

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1.0 INTRODUCTION

1.1 General

1.1.1 The licence for operation of a Nuclear Power Plant (NPP) is issued by AERB after satisfactory commissioning of the NPP. During the process of consenting, all aspects important to safety are assessed at various stages such as siting, construction, commissioning and operation. Preliminary assessment of feasibility of decommissioning of plant is also considered during this process.

1.1.2 As a part of the licensing condition, Periodic Safety Review (PSR) of NPP is required to be carried out at specified intervals and review reports are to be submitted to AERB.

1.1.3 PSR includes an assessment of plant design and operation against applicable current safety standards and operating practices, with an objective of ensuring a high level of safety throughout the NPP's operating lifetime.

1.1.4 For PSR, comprehensive multi-tier safety review of NPP is carried out considering the cumulative effects of ageing and irradiation, results of In-Service Inspection (ISI), system modifications, operational experience feedback, status and performance of safety systems and safety support systems, revisions of applicable safety standards, technical developments, manpower training, radiological protection practices, deterministic safety analysis, probabilistic safety assessment, hazard analysis, plant management structure, etc. PSR is carried out several times during the operating life of NPP.

1.1.5 PSR is a systematic safety assessment tool, carried out at regular intervals and also used in support of the decision making process for license renewal, where license has been granted for a limited period.

1.2 Objective

1.2.1 The objective of this safety guide is to provide guidance for carrying out systematic safety assessment during periodic safety reviews of NPPs. The safety guide also provides guidance on the corresponding submissions to be made to AERB.

This Safety Guide supplements provisions of AERB safety code on 'Nuclear Power Plant Operation', AERB/NPP/SC/O (Rev. 1) and AERB safety code 'Regulation of Nuclear and Radiation Facilities', AERB/SC/G.

1.3 Scope

1.3.1 This safety guide provides guidance for periodic safety review of operating NPPs. Although written specifically for periodic safety review of NPPs, guidance provided in this document can also be used for:

(a) Special reviews in response to major events of safety significance
(b) Limited Scope Safety Reviews (LSSR)

(c) Reviews carried out for restart of NPPs after extended shutdowns for major maintenance/ modification
(d) PSR of Research Reactors

1.3.2 This safety guide does not cover all aspects required to be reviewed for extension of plant operation beyond the design life.

1.3.3 Aspects related to security is not in the scope of this safety guide. Guidance on nuclear security measures for NPPs is provided in AERB documents on ‘Nuclear security requirements for NPPs’.

2.0 RATIONALE, OBJECTIVE AND SCHEDULE OF PERIODIC SAFETY REVIEWS

2.1 Rationale of Periodic Safety Reviews

2.1.1 An operating NPP undergoes continuous safety reviews which include routine and special safety reviews. However, such reviews may be of limited scope or focused on certain aspects of the plant only. For example, they may not always take into account improvement in safety standards and operating practices, cumulative effect of plant ageing and modifications, feedback from operating experience and wider development in science & technology. Hence, detailed and comprehensive safety reviews periodically are carried out in order to obtain an overall safety status of the plant for assuring safety for its continued operation. Such PSRs may also bring out areas of improvement, based on which suitable modifications may have to be incorporated to improve and maintain the required safety level.

2.1.2 PSR is performed to assess condition of the NPP and adequacy of the programmes, including ageing management programme, which are in place to maintain NPP safety. An integral element of PSR is the assessment of the extent to which the NPP would satisfy requirements and expectations set out in applicable current codes, standards and practices.

2.1.3 A recent PSR can provide reassurance that there continues to be a valid licensing basis taking account of, for example, plant ageing and current safety standards and operating practices.

2.2 Objective of Periodic Safety Reviews

2.2.1 The objective of PSR is to carry out a comprehensive assessment of safety during operation of an NPP for the period under consideration and to assure that:

(a) NPP as a whole (along with associated systems and facilities like heavy water up-gradation plants, away from reactor spent fuel storage facilities, waste management facility and other support facilities as applicable) continues to be capable of safe operation within the operational limits and conditions specified in 'Technical Specifications for Operation of the NPP'. It also ensures comprehensive review of aspects related to leadership and management for safety, radiological protection, emergency planning and environmental impact.
(b) Structures, Systems and Components (SSCs) important to safety, have not shown signs of deterioration and are capable of reliably performing their intended design functions.
(c) Provisions for plant safety in case of extreme external events beyond design basis as well as to handle severe accident conditions, and accident conditions in multiple units, along with monitoring provisions of site for external event related parameters are operable.
(d) Management of NPP is sensitive to safety related issues and management systems established at the NPP provide prompt response for taking effective measures to resolve the issues.
(e) Safety improvements are being implemented in timely manner.

(f) Any foreseeable circumstances that could threaten safe operation of the NPP are identified and appropriate actions are taken to ensure that the licensing basis remains valid.
(g) NPP as a whole, including the operator response and administrative controls, conforms to current national and/ or international safety standards.
(h) The licensing basis remains valid and the NPP has operated in a safe manner during the review period. Continued operation of the NPP till the next periodic review would not pose undue risk to the plant, plant personnel, public and the environment.

2.3 **Schedule for Periodic Safety Reviews**

2.3.1 Ten years is considered to be an appropriate interval for PSRs in view of the likelihood, within this period, of the following:

(a) Changes in national and international safety standards, operating practices, technology, underlying scientific knowledge or analytical techniques
(b) Any potential for cumulative effect of plant modifications to affect safety or the usability of safety documentation
(c) Identification of significant ageing effects or trends
(d) Accumulation of relevant operating experience, including that from any accidental occurrences or events having potential for accidental occurrences
(e) Changes in the way the plant is, or will be operated
(f) Changes in the natural, industrial (including airports & military installations) or demographic environment in the vicinity of the NPP
(g) Changes in staffing levels or in the experience of staff
(h) Changes in the management structure and procedures of the NPP management

2.3.2 The period between two PSRs should not be extended beyond ten years in order to avoid loss of continuity and enable timely identification of important safety issues and proper application of the knowledge and experience gained in previous reviews. AERB safety guide on 'Consenting Process for Nuclear Power Plants and Research Reactors' (AERB/SG/G-1) specifies the frequency of conduct of PSR.

2.3.3 Limited Scope Safety Reviews (LSSR) should be carried out in between two PSRs to evaluate primarily the safety performance and condition of safety related SSCs of the NPP. AERB safety code on 'Nuclear Power Plant Operation', (AERB/NPP/SC/O, Rev. 1) specifies the requirements pertaining to frequency of conduct of such reviews.

2.3.4 The PSR report should cover a period starting from the end of the period covered in the last PSR or from the date of initial operation.

2.3.5 Plant Management should initiate preparation of report on PSR sufficiently in advance. The length of the review process depends on the availability and retrievability of relevant information. Consideration should also be given to the fact

that review of safety factors is an iterative process and that the interface between safety factors also needs to be taken into account.

2.3.6 To ensure that sufficient time is available for review and assessment by AERB, Plant Management should submit PSR report to AERB six months prior to the end of current PSR period/ beginning of next PSR period. Report on LSSR should be submitted three months in advance. These reports should be independently reviewed by the Responsible Organization prior to submission to AERB. Overall programme of PSR and activities to be carried out are depicted in Figures 1 to 4. Schedules to be followed by Plant Management, Responsible Organization and Regulatory Body during preparatory and review phase of PSR are included separately in subsequent chapters of the safety guide.

3.0 SAFETY FACTORS IN PSR

3.1 General

3.1.1 Comprehensive assessment of plant safety is a complex task and is facilitated by dividing it into a number of safety factors having bearing on plant safety. The safety factors considered in the conduct of PSR include:

A. Safety factors relating to the plant

1) Plant Design
2) Actual Condition of SSCs
3) Equipment Qualification
4) Ageing Management

B. Safety factors relating to safety analysis

5) Deterministic Safety Analysis
6) Probabilistic Safety Assessment
7) Hazard Analysis

C. Safety factors relating to performance and feedback of experience

8) Safety Performance
9) Use of Experience from other NPPs and Research Findings

D. Safety factors relating to management

10) Leadership and Management for Safety
11) Procedures
12) Human Factors
13) Emergency Planning

E. Safety factors relating to the environment

14) Radiological Impact on Environment

Note: The grouping, order and numbering of safety factors listed above is not intended to imply any order of importance.

3.1.2 The safety factors listed above hould be considered for a comprehensive review of plant safety. All these safety factors are important for assessment of operational safety and may have a bearing on accident prevention and mitigation.

3.1.3 For LSSR, evaluation of safety factors 2, 8, 9 and 14 should be carried out for the five year period. Additional safety factors based on plant performance, national / international events, operating experience of other NPPs can be added during the

review of basis document (refer chapter 5). During the subsequent PSR, these safety factors should be evaluated for the remaining five years.

3.1.4 Quality Assurance (QA) is not considered as a separate safety factor because it should be an integral part of every activity affecting safety. It is assessed in its own right as an aspect of organisation and administration. Similarly, radiological protection is not regarded as a separate safety factor since it is related to most factors. The arrangements for radiological protection and their effectiveness should be reviewed as specific aspects of safety performance, procedures and actual physical condition of the plant.

3.1.5 Before initiating a PSR, a 'Basis Document' (refer chapter 5) should be prepared by plant management in consultation with AERB.

3.1.6 The review by plant management (refer Chapter 5) should determine the status of each safety factor at the time of PSR and whether the established operating regime is capable of identifying, preventing or mitigating potential failures before they could cause a radiological incident or become a threat to a safety barrier.

3.1.7 The fourteen safety factors considered in PSR are explained in the following subsections. Some elements of review for each safety factor are identified. These elements describe specific topics or activities within the safety factor, which should be reviewed. The elements listed may not be comprehensive to cover all topics or activities associated with the safety factor. Other elements, if found necessary, also can be covered during the review process. The objective, description, major elements of review and output of each safety factor is given in subsequent sections. The outputs brought out in the subsequent sections are only examples of expected findings arising out of review of safety factor.

Safety factors relating to the plant

3.2 Safety factor 1: Plant Design

3.2.1 Description

SSCs important to safety are designed to ensure highest level of safety that can be reasonably achieved for the protection of workers, the public and the environment. Design information, including information on the design basis, are available to provide for the safe operation, maintenance of the plant and to facilitate plant modifications. It is recognised that technology and scientific knowledge advance, safety requirements for design would change over time. Also plant modifications carried out over a period of time can cause cumulative effects on the design of the plant.

3.2.2 Objective

The objective of the review of this safety factor is to determine the adequacy of the existing design by assessment against current national, international standards and practices.

3.2.3 Major Elements of Review

These should include:

(a) Comparison of design of SSCs against the current design standards to identify strengths and weaknesses of the existing design.
(b) Cumulative effects of all modifications in the plant design since commissioning. (e.g. review of loading on electrical supplies or changes in heat load on cooling water systems).
(c) Changes in design basis/ assumptions, if any, which could have effect on plant design (e.g. changes in siting related data like seismic conditions, flood related data etc.).
(d) Adequacy of documentation related to original or modified design basis. The design related documents should be updated to reflect all modifications.
(e) Assessment of design concessions, if any, in the original design, should be revisited, for the period of license sought for.

3.2.4 Output

The assessment of this safety factor may lead into findings related to:

(a) Adequacy/ capability of the SSCs to meet latest design requirements such as defence in depth in the prevention and mitigation of events.
(b) Compliance of design with current safety and design standards including safety classification / seismic categorisation.
(c) Need for reassessment of safety margins against current standards/ design assumptions.
(d) Need for plant modifications/ procedural changes.
(e) Need for design re-evaluation, if design information of certain SSC is inadequate.
(f) Generation of inputs for revision of safety analysis report.
(g) Need for specification of new operating limits and conditions (Technical Specification for Operations).
(h) Need for improvement in documentation of the revised design basis (after modifications) of the plant/ SSC.

3.3 Safety factor 2: Actual condition of SSCs important to safety

3.3.1 Description

With time SSCs undergo ageing, deterioration and may face obsolescence issues. Some of the SSCs also might have gone through some modifications which may have some effect on the original design basis of the SSC. Hence, it is important to thoroughly review and document the condition of these SSCs. The consideration of actual condition of SSCs important to safety within the plant is important in assessing the safety status of the plant.

3.3.2 Objective

The objective of the review of this safety factor is to determine the actual condition of SSCs important to safety and so to consider whether they are capable and adequate to meet design requirements till next PSR. In addition, the review should verify that the condition of the SSCs is properly documented including maintenance, surveillance and in-service inspection programmes, as applicable. During review, it should be ensured that the actual state of the plant, including modifications, is considered.

3.3.3 Major Elements of Review

These should include:

(a) Evaluation of operating history of SSCs (failures observed) and existing/ anticipated ageing processes.
(b) Findings of tests and inspection which indicate the present physical condition of SSCs and validate its functional capability.
(c) Record of maintenance including condition monitoring on items important to safety.
(d) Adherence to chemistry control parameters for various systems.
(e) Status of SSCs with regard to obsolescence as well as anticipated obsolescence.
(f) Status of dependence on obsolescent equipment if substitute is not available.
(g) Availability of support facilities to the plant both on and off the site, including maintenance and repair shops.
(h) Modification to plant layout, structures, systems and components and its effect on safety.
(i) Process for documentation/ records of SSCs, in respect of inspection, modifications, developments and maintenance is in place and being followed.
(j) Adequate availability of critical spare parts and their maintainability.

3.3.4 Output

The assessment of this safety factor may lead into findings related to:

(a) Improvements in maintenance and testing programs.
(b) Identification of new mode of degradation, if any.
(c) Need to increase in scope of ISI to include larger sample size or an equipment that has not been covered so far.
(d) Need to employ new techniques or procedures for improving the capability of ISI.
(e) Need for replacement of SSCs.
(f) Need for reassessment of safety margins.
(g) Need for plant modifications/ procedural changes.
(h) Revision of safety analysis report and/ or specification of new operating limits and conditions.

3.4 Safety factor 3: Equipment Qualification

3.4.1 Description

Plant equipment important to safety should be properly qualified to ensure their capability to perform safety functions under all relevant operational states and accident conditions, including those arising from internal and external events and accidents (e.g. seismic, vibration, temperature, pressure, jet impingement, electromagnetic interference, irradiation, corrosive atmosphere and humidity and combinations thereof).

Qualification of plant equipment important to safety should be ensured through a process which includes generating, documenting and maintaining evidence that the equipment can perform its safety functions during its service life.

Equipment Qualification (EQ) should be an ongoing process starting from plant design to the end of service life and takes into account of plant ageing, plant modifications, repair and refurbishment, equipment failures and replacement, abnormal operating condition experienced by the equipment including adverse environment, safety analysis etc.

3.4.2 Objective

The plant equipment important to safety is qualified for certain environmental conditions. The objective of review of this safety factor is to determine whether this qualification is maintained through an adequate programme of maintenance, inspection and testing that provides confidence in the delivery of intended functions.

3.4.3 Major Elements of Review

These should include:

(a) Identification of equipment covered in the EQ master list, along with the environment (pressure, temperature, humidity, radiation level etc.) for which they are qualified.
(b) Assessment to confirm that all equipment that need EQ are covered in the EQ programme
(c) Validity/ Applicability (latest) of the standards and requirements used for EQ.
(d) Assessment to confirm that the installed equipment meets the qualification requirements.
(e) Availability and adherence to procedures for updating and maintaining qualification throughout the service life of the equipment are adequate.
(f) Availability and adherence to procedures for ensuring that modification and addition to SSCs important to safety do not compromise their qualification or have an adverse effect on the associated SSCs.
(g) Assessment of surveillance programs and feedback procedures used to ensure that ageing degradation of qualified equipment remains within acceptable range.
(h) Monitoring of actual environmental conditions and identification of parameters which can adversely affect the equipment performance.

(i) Identification of change in the EQ design parameters based on latest safety analyses.
(j) Protection of qualified equipment from adverse environmental conditions.
(k) Adequacy of the equipment qualification records.
(l) Quality management provisions to maintain equipment qualification.
(m) Analysis of equipment failures with causes attributed to failure in EQ and appropriate corrective actions to maintain EQ.

3.4.4 Output

The assessment of this safety factor may lead into findings related to:
(a) Compliance with EQ Programme.
(b) Adequacy of EQ Programme and inputs for additional qualification or protection needed for particular components including improving environment conditions.
(c) Replacement of SSCs whose condition does not meet the EQ requirement and availability of a replacement schedule for such SSCs.
(d) Improvements in maintenance program.
(e) Improvements in ageing management program.

3.5 Safety factor 4: Ageing Management

3.5.1 Description

All SSCs are susceptible to ageing which could eventually lead to impairment in their safety function and service lifetime. The rate of ageing depends on the type of material, environmental and operating stresses including effects of operational transients. It is important to understand, monitor and control/ mitigate the ageing of all materials and components which could impair safety functions. Managing the ageing of SSCs means predicting and/ or detecting the degradation of a plant component sufficiently in advance of the point wherein safety margins are eroded to unacceptable levels and taking appropriate corrective or mitigating actions.

3.5.2 Objective

The objective of review of this safety factor is to determine whether ageing aspects affecting SSCs important to safety are being effectively managed so that all required safety functions will be achieved for the design lifetime of the plant.

The review should also assess whether a systematic and effective ageing management programme comprising of relevant activities as surveillance, In Service Inspection (ISI), condition monitoring, maintenance, testing of surveillance coupons and surveillance samples, if applicable, chemistry control and feedback of operating experience required to establish adequate safety margin for SSCs important to safety throughout the service life is established. Special attention should be paid to cases of prolonged construction and extended shutdown.

Whereas safety factor ‘Actual condition of the SSCs’ establishes the actual condition of the SSCs at the time of the PSR, the safety factor of ageing is primarily concerned with the anticipated condition of the SSCs in the future.

3.5.3 **Major Elements of Review**

These should include:

(a) Ageing management policy, operating and maintenance policies.
(b) Adequacy of organization and resources for ageing management.
(c) Adequacy of manufacturing / construction/ erection records
(d) Assessment of criteria for selection of SSC for ageing management.
(e) Assessment of comprehensiveness of ageing management programme to ensure that it includes the following:
    - All SSCs important to safety
    - Any non-safety classified SSC whose failure might inhibit or adversely affect a safety function
    - SSCs that will be required for safety when the plant has ceased operation, for example spent fuel storage facilities, solid waste storage facility etc.
(f) Review of comprehensiveness of list of identified potential degradation mechanisms.
(g) Assessment of extent of understanding of dominant ageing mechanisms for SSCs and their impact on safety functions.
(h) Evaluation of models used to predict the evolution and advancement of ageing degradation with regards to current accepted practices pertaining to ageing degradation.
(i) Adequacy of relevant ageing indicators in respect of each SSC, measures taken to monitor & control ageing processes and mitigate the ageing effects.
(j) Control of system chemistry to prevent deterioration of equipment due to incompatibility/ corrosion.
(k) Assessment of acceptance criteria and required safety margins for SSCs important to safety.
(l) Availability of procedures/ mechanisms to assess the ageing degradation and residual life based on baseline data, operating and maintenance history especially for components that cannot be replaced and clear safety margins are available for their functions and the results thereof.
(m) Status of SSCs with respect to obsolescence and anticipated obsolescence.
(n) Analysis of results of inspection and testing programmes, trends in important safety parameters and failure data of components.
(o) Assessment of observed ageing degradation in accordance with appropriate guidelines in order to assess the integrity and functional capability of the SSCs.
(p) Review of physical condition of SSCs important to safety and any feature that could limit safety function.
(q) Adequacy of procedures/ operating guidelines for:
    - Controlling and/ or moderating the rate of ageing degradation
    - Managing the ageing of replaceable components to prevent or remedy unacceptable ageing degradation
    - For managing the obsolescence of technology / SSCs used in the plant.
    - Analysis of operating experience to identify age related degradation.
(r) Adequacy of process for an ongoing assessment of the effectiveness of ageing management programme and a feedback mechanism for its improvement.

(s) Assessment of availability / supply of compatible spares to address technological obsolescence of digital components

3.5.4 Output

The assessment of this safety factor may lead into findings related to:
(a) Identification of SSCs to be included in ageing management programme
(b) Improvement in maintenance programme or ageing management programme
(c) Requirements for increased surveillance/ replacement of particular SSC.
(d) Obsolescence, if any, in computer-based systems and time duration required to qualify them.
(e) Assessment of the residual life of irreplaceable components and assurance of safety margins for their function.

Safety factors relating to safety analysis

3.6 Safety factor 5: Deterministic Safety Analysis

3.6.1 Description

Comprehensive deterministic safety analysis should be conducted for each NPP, in order to confirm the design basis for SSCs important to safety and to evaluate the plant behaviour for postulated initiating events.

3.6.2 Objective

The objective of the review of this safety factor is to check the extent of validity and completeness of the existing deterministic safety analysis till the next PSR when following aspects are taken into account:

(a) The actual plant design, including all modifications of SSCs since the last update of the safety analysis report or the last PSR
(b) Current operating modes and fuel management
(c) The actual condition of SSCs important to safety and their predicted state at the end of the period covered by the PSR
(d) Completeness of the list of Postulated Initiating Events (PIEs)
(e) The use of modern, validated computer codes
(f) Current deterministic methods
(g) Current safety standards and knowledge (including research and development outcomes)
(h) The existence and adequacy of safety margins

Current analytical methods including computer codes should be used wherever re-analysis is required. All calculations should be plant and site specific. Any shared safety and safety related systems in multi-unit station should be carefully assessed. The simultaneous demand for shared safety related systems required by all the units in a multi-unit station should be considered for assessing the availability and effectiveness of such systems during accident conditions including Design Extension Conditions (DECs).

3.6.3 Major Elements of Review

These should include:

(a) Evaluation to confirm that the design basis used for deterministic safety analysis for items important to safety remain valid against current requirements, standards and good practices and that the plant behaviour for postulated initiating events is properly addressed as per the licensing basis requirements and deviations, if any, from the current regulatory requirements and standards need to be documented and addressed

(b) Verification of utilization of new knowledge in physical phenomena, analysis and modelling.

(c) Review of analytical methods, guidelines and computer codes used in the existing deterministic safety analysis with current requirement and a comparable list for a modern plant, including validation.

(d) Verification whether the assumptions made in performing the DSA reflect the actual condition of the plant.

(e) Verification whether the actual operational/ physical conditions of the plant meet the acceptance criteria for the design basis.

(f) Completeness of the postulated initiating events as per current regulatory requirement with appropriate consideration to feedback of operating experience from similar design both domestically and internationally. Deviations, if any, from the current regulatory requirements and standards need to be documented and addressed.

(g) Assessment of application of defence-in-depth principles.

(h) Appropriateness of deterministic methods used for implementing accident management programme including emergency operating procedures at the plant.

(i) To verify if calculated radiation dose and release for normal and accident conditions meet regulatory requirements

(j) Limits and permitted operational states (considering ageing, modifications, new findings, etc.)

(k) Verification that site characteristics, particularly flood and seismic, local meteorological conditions are latest.

(l) Findings of tests which validate the functional capability of items important to safety including the effectiveness of the shared safety systems to meet the simultaneous demand from all the units in a multi-unit station.

The review should include an evaluation of the supporting analyses for severe accidents. This should determine whether the arrangements aimed at preventing or mitigating severe core damage continue to be sufficient and whether any improvements are reasonable and practicable.

3.6.4 Output

The assessment of this safety factor may lead into findings related to:

(a) Assumptions used in analysis.

(b) Improvement in analysis methodologies and modelling.

(c) Need for modifications in design, procedures or reassessment of the licensing basis (like revised operational limits and conditions).

(d) Need for revision of safety analysis report.
(e) Need for additional postulated initiating events.
(f) Need for modification in design/ procedures, if any.
(g) Improvement of design in fulfilling the defence in depth principles, if any.
(h) Improvements in emergency preparedness programs

3.7 Safety factor 6: Probabilistic Safety Assessment

3.7.1 Description

Probabilistic Safety Assessment (PSA) should be conducted to identify weaknesses in the design and operation of the plant and, to evaluate proposed safety improvements. Plant PSA should be sufficiently up to date taking into account current requirements, design modifications, changes in operational practices and updated data obtained during the plant operation.

3.7.2 Objective

The objective of the review of this safety factor is to determine to what extent the existing PSA remains valid as a representative model of the plant when the following aspects have been taken into account:

(a) Changes in the design and operation of the plant.
(b) New technical information, for example, new initiating event.
(c) State-of-the-art methods for conducting PSA. For example human reliability modelling, common cause failure modelling etc.
(d) Updated/ new failure data.

Review of this safety factor should be carried out to determine whether the results of the PSA show that the risks are well within the acceptance criteria and well balanced for all postulated initiating events and operating states.

3.7.3 Major Elements of Review

These should include:

(a) Verification of analytical methods and computer codes used in the existing PSA and validation standards adopted for their appropriateness.
(b) Completeness of the set of postulated initiating events and hazards (both internal and external) and encompass the events experienced by the plant and the plants of similar design.
(c) Evaluation of whether assumptions made reflect the actual conditions of the plant, take account of all relevant operating experience and include all the modes of operation (full power, low power, shut down, refuelling etc.).
(d) Whether the scope (which should include all operational states and identified internal and external hazards), methodologies and extent (i.e. levels) of the PSA are in accordance with current regulatory requirement.
(e) Human reliability analysis carried out in the PSA should be reviewed to ensure that the actions are modelled on a plant specific and scenario dependent basis, and the current methods are applied.

(f) The extent to which the potential for unidentified effects of common cause events are taken into account in the model.
(g) Verification that omissions of hazards are based on site specific justifications and that these omissions do not weaken the overall risk assessment for the plant.
(h) Verification of consistency of the accident management programme for accidents conditions (design basis accident conditions and design extension conditions) with PSA results.
(i) Comparison of PSA results with relevant quantitative safety criteria (for example: system reliability, core damage and release of radioactive material) defined for the plant or set by AERB.
(j) Findings of tests which validate the functional capability of items important to safety including the effectiveness of the shared safety systems to meet the simultaneous demand from all the units in a multi-unit station.

3.7.4 Output

The assessment of this safety factor may lead into findings related to:
(a) Need for change in assumptions used in analysis, revision of safety analysis report.
(b) Improvement of design in fulfilling the defence in depth principles
(c) Need for modifications in design/ procedures.
(d) Improvements in PSA database and reliability.
(e) Improvements in accident management programme.
(f) Revision of operating limits and conditions.
(g) Improvements in emergency preparedness programs
(h) Compliance with quantitative safety criteria specified by the Regulatory Body (e.g. Core Damage Frequency, Large Early Release Frequency). For limited scope PSA, the 'out of scope' elements and their potential contribution towards the full scope criteria needs to be clearly brought out for risk-informed regulatory decision making.

3.8 Safety factor 7: Hazard Analysis

3.8.1 Description

Hazard[4] analysis is the process of recognizing hazards that may arise from a system or its environment, documenting their unwanted/ unsafe consequences and analysing their potential causes as per prevailing AERB guidelines at the time.

To ensure the delivery of required safety functions and operator actions, SSCs important to safety, including the control room and the Onsite Emergency Support Centre (OESC) should be adequately protected against relevant internal and external hazards considered separately.

3.8.2 Objective

The objective of the review of this safety factor is to determine the adequacy of protection of the plant against internal and external hazards taking into account

[4]Condition, event, or circumstance that could lead to or contribute to an unplanned or undesirable event

the actual plant design, actual site characteristics and updated data, the actual condition of SSCs and their predicted state at the end of the period covered by the PSR and current analytical methods, safety standards and knowledge.

Data collected from monitoring of site related parameters should be processed to evaluate its impact on the design basis including revision of the design basis, if warranted. In case of revision of the design basis, the plant safety should be reviewed with respect to the revised design basis.

3.8.3 Major Elements of Review

These should include:

(a) Review of completeness of list of internal and external hazards (as per AERB Safety Code on Site Evaluation of Nuclear Facilities AERB/NF/SC/S) considered taking into account current regulatory requirements, applicable international practice, operating experience from other plants, changes in plant design, climate change, and changes in transport and industrial activities near the plant site.
(b) Assessment of magnitude and associated frequency of occurrence of hazard.
(c) Assessment of internal and external design basis hazard taking into account the actual plant design, the actual condition of SSCs with allowance given to ageing, site characteristics by using current regulatory requirements, analytical techniques and updated data.
(d) Evaluation of whether the probability or consequences of design basis hazard are sufficiently low so that no specific protective measures are necessary or that the preventive and mitigating measures against the hazard are adequate.
(e) Evaluation of current understanding of environmental effects.
(f) Evaluation of whether fire hazard analysis is current and updated and risk due to fire is sufficiently low.
(g) Adequacy of the procedures and provisions used to mitigate the consequences of a hazard including consideration to actual events, in particular those that have occurred at plant and also hazards those could arise due to new industrial facilities (which were not around before) and also due to potential accidents those could take place in those facilities.

3.8.4 Output

The assessment of this safety factor may lead into findings related to:
(a) Need for reassessment of safety margins.
(b) Detection of hazards or improve mitigation of the consequences of hazards e.g. flood barriers need raising, flood warning systems and fire barriers needs installation etc.
(c) Need for plant modification processes or maintenance procedures.
(d) Need for reassessment of equipment qualification.
(e) Generation of inputs for revision of safety analysis report.
(f) Need for revision of procedures
(g) Need for improvement of the emergency preparedness program

Safety factors relating to performance and feedback of experience

3.9 Safety factor 8: Operational Safety Performance

3.9.1 Description

Safety Performance is usually determined from assessments of station's operating experience which includes Event Reports (ERs), Significant Event Reports (SERs), safety system unavailability records, radiation dose data, radiological status (area radiation levels, contamination level of floor, air and system etc.) and trend, generation of radioactive wastes and discharge of radioactive effluents.

3.9.2 Objective

The objective of review of this safety factor is to determine whether safety performance of the NPP including its trend from records of station's operating experience including evaluation of root causes of plant events indicate any need for safety improvements.

Review of safety performance for the purpose of PSR should be restricted to operating experience at the plant under review. Use of experience from other plants and research findings is covered under safety factor 9 on 'Use of Experience from other NPPs and Research Findings'.

3.9.3 Major Elements of Review

These should include:

(a) Assessment of adherence to Technical Specifications for Operation of NPP/ Station Policy.

(b) Trend analysis of safety related data (unplanned trips, unavailability of safety system components, and actuation/functioning of safety systems, safety related systems and features (on demand/test & failures during test)) to identify unsafe conditions/practices or trends, potential future safety concerns or deteriorating safety performance. Where relevant, the results of the previous PSR should be examined to detect any long term trends in deteriorating safety performance.

(c) Analysis of Low Level Events (LLEs), Near Miss Incidents and events.

(d) Evaluation of results of assessment of safety performance indicator during each year of plant operation to highlight potential safety problems if any.

(e) Root cause analysis of safety related events and implementation of recommendations arising out of these analyses.

(f) Basis for selecting and recording safety related operational data, including those for maintenance, test and inspection.

(g) Assessment of failure data to confirm that they are commensurate with the numbers considered in PSA.

(h) Assessment of replacements/ Modifications of SSCs important to safety (if any) due to failures or obsolescence and their trend analysis.

(i) Review of feedback of safety related operational data into the operating regime.

(j) Assessment of industrial safety issues to confirm that the intents of current industrial safety standards in addition to Atomic Energy (Factories) Rules is being met.
(k) Assessment of radiation risk to plant personnel, public and environment by review of records of exposure to persons (regular and temporary workers) and exposure to persons in excess of prescribed level, records of radioactive effluent, records of on-site and off-site radiation monitoring data to determine whether these are within prescribed limits, as low as reasonably achievable and adequately managed.
(l) Trending of budgeted dose vs actual dose consumed during Biennial Shutdowns (BSDs).
(m) Analysis of data of the quantities of radioactive waste generated, processed and released to environment to confirm it is within prescribed annual limits and are as low as reasonably achievable.
(n) Assessment of implementation status of regulatory recommendations/ safety issue.

Consideration should be given to the effects of any changes in operation at the plant (for example, the use of a new design of fuel) on safety performance etc.

3.9.4 Output

The assessment of this safety factor may lead into findings related to:
(a) Identification of deteriorating safety performance and corrective actions for minimising potential safety concerns.
(b) Improvement in the ALARA practices related to cumulative radiation exposure, and minimization of radioactive waste including minimization of the waste.
(c) Need for safety improvements based on the root cause(s) identified by the review.
(d) Generation of inputs for updating PSA and Final Safety Analysis Report (FSAR).

3.10 Safety factor 9: Use of Experience from other NPPs and Research Findings

3.10.1 Description

Feedback from other nuclear power plants / nuclear facilities (domestic and international), and sometimes from non-nuclear facilities, together with research findings can reveal unknown weaknesses in safety or help in the solution of existing problems.

In order to ensure this, a method for receiving and assessing the feedback information from various sources (such as IAEA-Incident Reporting System, WANO, COG, INPO etc.) should exist at NPP.

3.10.2 Objective

The objective of the review of this safety factor is to determine whether an adequate mechanism regarding feedback of safety experience from other NPPs / nuclear facilities, non-nuclear facilities and the findings of research exists at the plant and whether this is used to introduce safety improvements at the plant or within the plant management.

3.10.3 Major Elements of Review

These should include:

(a) Arrangements for feedback of experience relevant to safety from other NPPs / Nuclear Facilities (national and international) are adequate.
(b) Arrangement for feedback of experience from other relevant non-nuclear facilities (national and international), whenever feasible are adequate.
(c) Arrangements for receipt of information on the findings of relevant research programmes are adequate.
(d) Process of assessing (including screening) the experience feedbacks & information gained from above sources and identification of actions is well established.
(e) Assessment if identified actions including plant modifications and other major actions resulting from the review of above are adequate.
(f) Assessment of timely implementation of identified actions including plant modifications and other major actions resulting from the review of above.
(g) Arrangements of proper record keeping & documentation for the operating experience feedback process are adequate.
(h) Provisions for periodic self-assessment regarding operating experience and research findings exist.

3.10.4 Output

The assessment of this safety factor may lead into findings related to:

(a) Need for consideration of additional Operating Experience (OE) inputs.
(b) Corrective actions based on OE programme.
(c) Effectiveness of the Operating Experience Feedback (OEF) programme.
(d) Improvements in arrangements for receipt of operating experience feedback from other plants as well as research programmes (including international programmes), if required.
(e) Need for improvement in dissemination of operating experience feedback within the Plant Management.

For the first PSR, all relevant national as well as international experience gained in the preceding years should be reviewed and corrective actions should be provided.

Safety factors relating to management

3.11 Safety factor 10: Leadership and Management for Safety

3.11.1 Description

Leadership[5] in safety matters is required to be demonstrated at the highest levels in an organization. Safety should be achieved and maintained by means of an effective management system. The management system should integrate all elements of management so that requirements for safety are established and applied coherently with other requirements, including those for human performance, quality and security, and so that safety is not compromised by other requirements or demands. The management system also should ensure the promotion of safety culture, the regular assessment of safety performance and the application of lessons learned from experience.

3.11.2 Objective

The objective of the review of this safety factor is to determine whether the leadership and management for safety at the plant is adequate and effective to ensure safe operation of the plant. It is also to confirm if the organisation is live to the developments in technology and operational practices in the field of NPP operation. For an objective review and to eliminate subjectivity, it is desirable to involve specialists from outside the Plant Management having appreciation of nuclear safety for the objective and focussed review of this safety factor.

3.11.3 Major Elements of Review

These should include:

(a) Established and documented delineated roles and responsibilities of individuals and groups along with delegation of powers and accountabilities and interfaces within the organization at all levels. Assessment of leadership at all levels in the organisation (needs to be instituted). Assessment of the roles and responsibilities for up keep of shared systems/ resources in case of multi-unit sites.

(b) Feedback of experience relating to organisational and management functions and the process for managing organisational changes, organization's policy for safety demonstrating commitment to improving safety performance.

(c) Established measurable safety goals in line with strategies, plans and objectives at various levels in the organization.

(d) Mechanism for periodic review of such established safety goals and corrective actions in case of observed deviation.

(e) Adequacy of Integrated Management System for necessary safety management of the organization and its activities (e.g. operation,

[5] 'Leadership' is the use of an individual's capabilities and competences to give direction to individuals and groups and to influence their commitment to achieving the fundamental safety objective and applying the fundamental safety principles, by means of shared goals, values and behaviour.

maintenance, QA, maintenance and replacement policies, procurement process and availability and management of safety system spares etc.) including process for change management.

(f) Results of self-assessment and independent assessment of established management systems and further actions taken/ identified.

(g) Mechanism to encourage reporting of safety related problems, to develop questioning and learning attitude, and to correct acts and conditions that are adverse to safety.

(h) Adequate mechanism for use of graded approach in planning, staffing and resource allocation based on safety significance is established.

(i) Mechanism for configuration management.

(j) Mechanism for review, verification, approval and documentation of modifications in design of the facility.

(k) Establishment of formal arrangements or mechanisms for establishing formal arrangements with external organisations for assigned tasks where detailed specialised knowledge is not available. Human resource management process that ensures adequate qualified human resources.

(l) Staff training facilities and programmes to ensure necessary in-house competence at all levels.

(m) Mechanism to ensure individuals at all level are competent to perform their assigned tasks and to work safely and effectively and understand standards that they are expected to apply in completing their tasks.

(n) Mechanism to maintain and enrich knowledge management within organisation.

(o) Arrangements for ensuring that suppliers of items, products and services important to safety adhere to safety requirements.

(p) Mechanism for follow-up and timely implementation of recommendations made by various agencies such as Plant Management, AERB.

(q) Arrangements for fostering and sustaining a strong safety culture at all levels

(r) Mechanism to assess Safety Culture at all levels at regular intervals, results of such assessment and corrective actions taken to improve.

(s) Mechanism to maintain independence of QA, Industrial & Fire Safety and Radiation Safety Officer (RSO).

(t) Quality Assurance Programme and regular QA audit involving independent assessors.

(u) Availability of readily retrievable comprehensive records on baseline information, operation and maintenance.

(v) Mechanism for communication of information and management expectations to the staff.

3.11.4 **Output**

The assessment of this safety factor may lead into findings related to:

(a) Improvements in organization structure, if any, organizational roles and responsibilities, prioritization of safety issues, safety culture assessments.

(b) Need for improvements in work processes (how work is specified, prepared, reviewed, performed, recorded, assessed, and improved), safety procedural

compliance, control of documents and records, communication process, organizational change management.

(c) Generation of inputs for quality assurance programme and its documentation.
(d) Safety culture assessment and trend analysis.

3.12 Safety factor 11: Procedures

3.12.1 Description

Procedures are required to be established to operate, maintain and manage the NPP in a planned, systematic and safe manner in order to assure that there is compliance with Operating Limits and Conditions (OLCs) and other regulatory requirements, consistency with the design intent and for management of the plant under abnormal and accident conditions.

Availability of updated, comprehensive, unambiguous and formally approved procedures based on assumptions, data and findings of the safety report, results of commissioning tests and operating experience and their compliance should ensure effectiveness of design and defence in depth.

3.12.2 Objective

The objective of the review of this safety factor is to determine whether the plant management's processes for managing, implementing and adhering to procedures are adequate and effective and support plant safety.

3.12.3 Major Elements of Review

These should include:

(a) Arrangements for regular review and update of these procedures based on assumptions and findings of the safety analysis, plant design and operating experience.
(b) Availability of updated and approved procedures for all plant states (including guidelines for accident and post-accident management), including maintenance, test, inspection, training and work permit procedures.
(c) Process for identification of requirement of new procedures.
(d) Process in place to ensure changes in existing procedures or development of new procedures for plant modifications and weeding out of outdated procedures.
(e) Process for development/ modification and validation of any procedure impacting safety.
(f) Assess the use of Human, Organization and Technological factors while development of procedures.
(g) Established process in place to ensure development/ changes in procedure based on Root Cause Analysis of events.
(h) Procedures for radiation protection, including those for on-site transfers of radioactive material (Procedures for radioactive effluents and waste management).

(i) Assessment of adherence to plant procedures and other guidelines by plant personnel.

3.12.4 Output

The assessment of this safety factor may lead into findings related to:

(a) Generation of inputs to process for development, elaboration, validation, acceptance, modification, and withdrawal of procedures.
(b) Need for development of new procedures and clarity in existing procedures.
(c) Effectiveness and adequacy of procedures and procedure use.

3.13 Safety factor 12: Human Factors

3.13.1 Description

Human factors influence all aspects of safety of an operating NPP. They are significant elements of the plant safety culture. Some examples of Human Factors are organizational & management structures, policies & programs, allocation of functions to humans & machines, design of man-machine interfaces, staffing provisions, work schedules, design of procedures, training and the physical work environment.

3.13.2 Objective

The objective of review of this safety factor is to determine the status of various human factors that may affect the safe operation of the plant and to identify improvements, wherever required.

The review should determine whether plant personnel adhere to plant procedures and guidelines and whether operator actions claimed to be in support of safety are feasible and properly supported.

3.13.3 Major Elements of Review

These should include:

(a) Adequate staffing levels for the operation of the plant with due recognition of absences, shift working and overtime restrictions.
(b) Availability of qualified staff on duty at all times.
(c) Adequacy of programmes for initial training, refresher training, need-based and skill up-gradation training including the use of simulators.
(d) Operator actions needed for safe operation have been assessed to confirm that assumptions and claims made in safety analyses (e.g. PSA, DSA and hazard analysis) are valid.
(e) Assessment of use of human performance improvement tools to promote error free execution of work.
(f) Existence of appropriate fitness for duty guidelines relating to hours, types and patterns of work & good health.

(g) Existence of policies for maintaining the expertise/skills of staff and for ensuring adequate succession management in accordance with good practices.
(h) Established processes for employing suitably qualified external technical, maintenance or other specialist staff.
(i) Review of following aspects related to human-machine interface:
  - Design of the control room and other work stations.
  - Human information requirement and workload.
  - Clarity and achievability of procedures
(j) Mechanism for feedback of operating experience especially for human performance related failures and timely implementation of identified corrective actions.
(k) Analysis of near miss incidents, events and significant events for human related failures and their study and rectification process by way of addressing them to prevent their recurrence.

3.13.4 Output

The assessment of this safety factor may lead into findings related to:
(a) Improvements in training programs, knowledge management and competency management.
(b) Generation of inputs for staff selection & recruitment and succession management.
(c) Need for improvement in operating, maintenance & engineering practices and human-machine interface.
(d) Effectiveness of procedure use and adherence by plant personnel.
(e) Improvement in the procedures, modifications in the systems/ components.

3.14 Safety factor 13: Emergency Planning

3.14.1 Description

The design and operation of a plant is required to prevent or otherwise minimize release of radioactive substances that could give rise to risks to workers or the public or to the environment.

Emergency planning for the possibility of such releases is a prudent and necessary action, not only for the Plant Management but also for local and national authorities.

3.14.2 Objective

The objective of review of this safety factor is to determine that the plant management has adequate staff, facilities, resources, plans and preparedness to deal with emergencies. The arrangements of plant management are coordinated adequately and periodically exercised with local, state (s) and national authorities.

3.14.3 Major Elements of Review

These should include:

(a) Adequacy of plans, procedures and organisational structure for emergency response, and compliance to current regulatory requirements
(b) Adequacy of on-site equipment, facilities and availability of trained personnel for handling emergencies and response, including maintenance and storage of emergency equipment
(c) Applicable reference levels and criteria for Emergency Preparedness and Response.
(d) Capability for emergency radiological surveillance, source term estimation and dose projection.
(e) Availability and efficacy of Decision Support System for emergency response
(f) Adequacy of on-site and off-site emergency centres,
(g) Transport, medical and communication arrangements,
(h) Provisions for interaction with relevant organization such as district authorities, CMG-DAE, AERB, NDMA, SDMA, DDMA, off-site EMG Director etc.
(i) Public Awareness programme on Emergency Preparedness and Response
(j) Effect of change in the number and type of facilities on the plant site.
(k) Change in local population distribution and effect of recent residential and industrial developments around the site.
(l) Review of records of emergency exercises/drills and lessons learnt from them.

3.14.4 Output

The assessment of this safety factor may lead into findings related to:

(a) improvement of effectiveness of Decision Support System, and response actions, especially during the emergency exposure situation
(b) Generation of inputs for updating emergency plans in accordance with the results of current safety analyses, accident mitigation studies and good practices.
(c) Need for administrative improvements in emergency plan.
(d) Improvement in communication arrangements.

Safety Factors relating to the environment

3.15 Safety factor 14: Radiological Impact on Environment

3.15.1 Description

Plant Management should have in place an established and effective monitoring programme that provides data on the radiological impact of the plant on its surroundings.

3.15.2 Objective

The objective of the review of this safety factor is to determine whether there is an adequate programme for monitoring and assessment of radiological impact of the

plant on the environment, which ensures that effluent releases are properly controlled and are as low as reasonably achievable.

3.15.3 Major Elements of Review

These should include:

(a) Availability of an established and effective surveillance programme that provides radiological data on the surroundings of the plant site.
(b) Review of comprehensiveness of the programme for monitoring and trending of all relevant environmental aspects such as concentration of radionuclides in air, water (including river water, sea water and groundwater), soil, agricultural and marine products and animals. Reasons for significant variation in monitored values, and corrective actions taken.
(c) Availability and trending of records of effluent releases in comparison with permissible limits.
(d) Off-site monitoring for radiation levels using reliable methods including impact of NPP operation as assessed by Environmental Survey Laboratory (ESL) near NPP site.
(e) Availability and effectiveness of alarm systems to detect unplanned release of radioactive material from on-site facilities.
(f) Comparison of periodically collected radiological data from the plant surroundings with the values measured before the NPP was put into operation.
(g) Availability of adequate instruments, duly calibrated and operational, and sampling methods for radiation survey, analysis and analytical tools to assess public dose from environmental sample analysis, radiation monitoring, micro meteorological data and effluent analysis data.
(h) Assurance that the sampling, measurement and analytical methods and their independent verification are in line with current standards.
(i) Identification of potential new sources of radiological impact by examination of plant modifications and actual condition of SSCs important to safety.
(j) Availability of micro meteorological data, wind pattern, predominant wind direction and dilution factors at the site.
(k) Consideration of changes in the use of areas around the site for modification in monitoring programme.

3.15.4 Output

The assessment of this safety factor may lead into findings related to:

(a) Improvement in Environmental Surveillance Programme such as analytical methods, equipment etc.
(b) Revision of documents establishing the Environmental Surveillance Programme based on the findings, if any.
(c) Inputs to minimize the release of radionuclides to environment.

4.0 ROLES AND RESPONSIBILITIES

4.1 The responsibility of conducting PSR and reporting the safety significant observations to AERB lies with the Plant Management.

4.2 As PSR is an important aspect of the Safety Management System, internal review of the same assumes a significant responsibility. The PSR report should be internally reviewed by the Responsible Organization before submission to AERB.

4.3 Prior to conducting PSR, the Plant Management should submit the PSR basis document, criteria for assessment for each safety factor, scope and programme for conducting the PSR. Plant management should ensure availability of sufficient expertise for conducting PSR.

4.4 Plant Management can use expertise from outside agencies for all such factors where sufficient in-house resources are not available for evaluation and review (such as 'Leadership and Management for Safety' and 'Human Factors'). The engagement of external agencies does not diminish the responsibility of Plant Management for carrying out adequate PSR.

4.5 The Plant Management should carry out PSR, and submit reports such as Safety factor reports, Global assessment report (refer clause 5.2.5) and Integrated implementation plan to AERB, after review by the Responsible Organization. Head of Plant Management should submit a certificate of safety assurance and undertaking as per the format given in Appendix 2 along with the PSR report. Steps for carrying out LSSR are similar to PSR, including the requirement of preparation of basis document, global assessment report & integrated implementation plan.

5.0 REVIEW PROGRAM

5.1 Basis Document

5.1.1 The starting point of a PSR is a Basis Document which is an agreement between the Plant Management and AERB on the scope, requirements, and expected outcome from the PSR.

5.1.2 As part of this agreement, Plant Management in consultation with AERB should determine an appropriate point in time to 'freeze' the set of documents to be reviewed and the status of the safety performance of the plant to be taken as a basis for the PSR, so as to ensure consistency across all parts of the PSR. This point of time will be frozen in the Basis Document.

5.1.3 The Basis Document should cover scope, major milestones including cut-off dates[6] and methodology, applicable safety factors, applicable national and international standards, structure of the documentation. The process for categorising, prioritising and resolving findings should also be agreed upon and set out in the Basis Document.

5.1.4 The Basis Document should be independently reviewed by the Responsible Organization and submitted to AERB eighteen months prior to the end of the current PSR period/ beginning of the next PSR period. Recommended contents of the PSR basis document are given in Appendix 1.

5.2 Activities by Plant Management

The PSR activities can be divided into three steps:

a) Preparation for the PSR;
b) Review of the safety factors;
c) Analysis of the findings (including the global assessment), preparation of the report and preparation of a program for safety improvements.

Preparation for the PSR

5.2.1 Plant Management should create a group to prepare the program of PSR in consultation with designers and AERB. After completion of PSR, the report and findings should be submitted to plant management for review and approval (Refer Fig. 2).

5.2.2 To ensure the appropriate quality and format of the PSR documents, a quality assurance plan should be prepared that, among other things, defines the requirements for the preparation and verification of the PSR documents. The quality assurance plan should also ensure that all reviewers use the same input data to maintain consistency across all areas of the review.

[6] beyond which changes to codes and standards and new information will not be considered

Review of the Safety Factors

5.2.3 To review each safety factor, systematic approach document should be prepared. For review, information should be gathered from FSAR, plant walk-through, national and international operating experience etc. Relevant codes, standards and practices should be identified against which the review should be conducted. Areas where either the licensing basis or current standards and practices are not achieved should be identified.

5.2.4 The safety factors should be reviewed for all relevant operating and accident conditions, using current national and applicable international safety standards and operating practices as identified in the PSR Basis Document. The review method applied should be systematic and independent of the ongoing regulatory oversight of the plant.

5.2.5 Plant Management should perform a global assessment of safety at the plant by integrating results of individual safety factors reviews. The Global Assessment Report (GAR) should include all findings and proposed improvements from the safety factor reviews and interfaces between different safety factors. An Integrated Implementation Plan (IIP) of the identified safety improvements based on Global Assessment should also be prepared.

5.2.6 The review should evaluate that for each safety factor, to what extent current safety standards and practices are complied with. The level of plant safety should be determined by the combined effect of all safety factors. Shortcomings may be present in individual safety factors, but their combined effect should be reviewed for acceptability. Necessary corrective actions, as brought out in the GAR and IIP, should be determined and implemented.

5.2.7 The review should be carried out with the help of appropriately qualified specialists. The plant management may involve external consultants to examine specific elements for an objective review.

5.2.8 In case there is a fleet of similar reactors, the first unit is generally considered as the reference plant. If the review and assessment of certain safety factors has been completed satisfactorily for the reference plant, review of the same factor for other plants of the fleet should focus on those aspects or features for which the specific plant differs from the reference plant and in particular the plant-site interaction aspects. In the safety factor review report, the applicant should clearly indicate which aspects of the reference plant are affected by this plant, and should provide explanation/justification for the differences. It is also necessary to demonstrate that these (different) aspects do not have any adverse effect on the remaining (unchanged) features/ aspects of the plant.

5.2.9 The review of safety factors should identify findings of the following types:

- Strengths: Where current practice is equivalent to good practices as established in current codes and standards etc.
- Deviations/ shortcomings: Where current practices are not of a standard equivalent to current codes and standards or industry practices, or do not meet

the current licensing basis, or are inconsistent with operational documentation for the plant or operating procedures.
- Conclusion of safety factor based on strengths and deviations/shortcomings.

5.2.10 Deviations/ shortcomings should be divided into:
- Deviations for which no reasonable and practicable improvements can be identified
- Deviations for which identified improvements are not considered necessary
- Deviations for which safety improvements are considered necessary

Analysis of the findings

5.2.11 The safety significance of all findings should be evaluated using deterministic and probabilistic methods as appropriate. Based on the review and analysis, important observations should be recorded. Safety significance of the observations should be evaluated and required safety improvements should be identified (Refer Fig. 3) If no safety improvement can be identified that is reasonable and practicable, a justification for this should be prepared for each deviation/ shortcoming. After review and approval by Plant Management, the PSR Global Assessment Report (GAR) and Integrated Implementation Plan (IIP) of identified safety improvements should be independently reviewed by the responsible organization, and thereafter submitted to AERB. (Refer Fig. 4).

5.2.12 If safety improvements in the plant require significant time, research & development etc. then Plant Management should inform the same to AERB and propose interim safety measures to improve safety for reducing risk and the justification for continued operation of the plant.

5.2.13 The approach taken for deviations/ shortcomings should be justified by the operating organization and agreement by the regulatory body should be sought.
- In the case of deviations/ shortcomings for which no reasonable and practicable improvements can be identified, the reason(s) should be documented and the issue revisited after an appropriate period of time to determine whether a practicable solution is available.
- For deviations/ shortcomings for which safety improvements are not considered necessary, the reason(s) should be documented and the action considered completed.
- Deviations/ shortcomings for which safety improvements are necessary, including updating/ or extending of plant documentation or operating procedures, should be categorized and prioritized according to their safety significance. The categorization and prioritization of safety improvements may be performed on the basis of deterministic analyses, probabilistic safety assessment, engineering judgement, etc. Safety improvements from the safety factor reviews, together with safety improvements resulting from the global assessment, should be included in the operating organization's IIP. The outputs from the review of some safety factors can be relevant as inputs to the review of other safety factors.

5.2.14 For accidents having off-site impact, the site characteristics should be reviewed, along with land usage and off-site population growth. External event related parameters should be monitored at site. The impact of external hazards such as fire, floods, earthquake, explosion and aircraft crashes on overall safety should be considered where necessary in both deterministic and probabilistic analyses and should take account of latest available information including revised values of external design parameters, if available. For floods and earthquakes, extreme nature of these hazards should also be considered.

5.3 Regulatory Reviews

5.4 AERB will review PSR Basis Document and program for conducting PSR. AERB may specify and intimate any additional requirements in the light of operational experience and current safety practices.

5.5 AERB will review the safety assessment carried out by Plant Management with respect to continued operation of the plant upto next PSR (as per the basis for acceptability of continued plant operation in Chapter-6). AERB will review the PSR report especially focusing on safety significant observations and identified safety improvements.

5.5.1 AERB will review the PSR report and take necessary regulatory decisions for the proposed safety improvements, if any, before the end of current PSR period which is the beginning of next PSR period[7].

5.5.2 The safety improvements should be implemented by plant management within the agreed timeline. If any new additions / modifications becomes necessary due to review processes / regulatory requirement or as evidenced by new experience or topic that become relevant, the regulatory body may ask the plant management to include such an addition in the PSR Basis Document. The overall process for undertaking the PSR of a nuclear power plant is shown in Fig.-1.

[7] Any significant event relevant to the plant after the PSR cut-off date and before license renewal should also be part of PSR. Separate document incorporating the same may be submitted, if PSR has already been submitted.

6.0 BASIS FOR ACCEPTABILITY OF CONTINUED PLANT OPERATION

6.1 The assessment should provide assurance of safety of the plant over the period addressed in the PSR on the basis of a balanced view of the findings from the reviews of all the safety factors. It should be judged that upto what extent the plant meets the current safety standards and operating practices.

6.2 In the event that the PSR identifies a finding that poses an immediate and significant risk to the health and/ or safety of workers or the public or to the environment, the Plant Management should take prompt action and not wait until the end of the PSR for taking corrective action or implementing safety improvements.

6.3 The review should identify any differences between the present safety status of the plant and the current safety requirements and practices. It may not be possible that an NPP built to earlier standards may meet all the current safety standards. A comparison should be made to identify the shortcomings and remedial measures if any should be proposed with a time frame for addressing such shortcomings. It is recognized that some of the design aspects and plant layouts are difficult to modify. For such cases the procedure requires analysing the risk associated with the gap areas and addressing such differences with additional provisions, modification in operating and maintenance practices and providing justification for continued operation.

6.4 Differences classified as shortcomings should be assessed and an overall judgment on the acceptability of continued operation, with the shortcomings remaining after all corrective actions are implemented, is required. Aspects involved in this judgment may include:

6.4.1 Remaining period of operation proposed by the Plant Management: Consideration should be given to the actual benefit to safety that the corrective action will achieve and the duration of the benefit (the remaining planned lifetime of the plant). If the period is sufficiently short, the risk associated with continued operation with some weaknesses may be judged acceptable during this period, with interim remedial measures in effect.

6.4.2 Deterministic consideration of the total effect of all unresolved shortcomings, safety improvements and strengths on the safe plant operation.

6.4.3 Probabilistic safety assessment can be used as a measure of the risk posed by each of the unresolved shortcomings.

7.0 POST REVIEW ACTIVITIES

7.1 PSR of the plant is complete when all analyses and required corrective actions such as modifications to the plant and/or procedures have been implemented. AERB should be informed when safety improvements are implemented or there is any significant delay in completing the improvements later than the agreed time schedule. Outstanding work should be agreed upon between AERB and the Plant Management.

7.2 All relevant documents, for example the operating and maintenance procedures and training materials as well as the design, operation and licensing documentation should be revised to reflect the actual configuration of the plant following the PSR. Based on the need for revision identified during PSR, the final safety analysis report should be updated to incorporate all the design changes completed and results of safety analyses obtained in support of the safety improvements.

7.3 Documentation of PSR should be stored and preserved in a suitable manner, which would allow easy retrieval as well as examination, by the Plant Management and AERB. This documentation should contain the final version of the PSR documents and information on lessons learnt from it.

Appendix 1: Recommended contents of the PSR basis document

The PSR basis document should include three main parts:

(1) General

- The scope [limited (typical content given in Annexure) or full] and objectives of the PSR (including review of shared facilities/systems at the site) and the operating period that will be considered for the review
- The cut-off dates to be used, that is, the dates beyond which updates to standards and codes and new information (for example, more recent plant operating experience) will not be considered during this PSR
- The plant's licensing basis at the time of initiating the PSR
- Relevant regulatory requirements
- The list of safety factors to be reviewed within the PSR and interface between them
- A description of the systematic review approach to be used to ensure a complete and comprehensive review
- Processes for identifying, categorizing, prioritizing and resolving deviations/ shortcomings
- The process for ensuring any immediate and significant risks to the health and/or safety of workers or the public or to the environment identified during the PSR will be addressed without delay
- Guidance for preparation of the integrated implementation plan of safety improvements
- The systematic method to be used for recording outputs from the PSR, including the proposed formats of safety factor reports and the final PSR report, including the integrated implementation plan of safety improvements.

(2) Safety factors

The following information should be provided for each safety factor:

- Objectives and scope of the review
- The applicable regulatory requirements, national, international and industry safety standards, codes and methods, and operational practices selected as the basis for the safety factor review and, where relevant, their hierarchy
- The input documents and processes to be reviewed
- The specific methodologies to be used for the review and a justification for the approach to be followed
- Expected outputs.

(3) Project plan for the PSR

- Organization of the project, including roles and responsibilities
- Time schedule including any major milestones and cut-off dates
- Project and quality management processes
- Processes for ensuring consistency between separate safety factor reviews, for example, for establishing a common set of technical databases
- Training
- Internal communications
- The plan for communicating and interfacing with and gaining relevant approvals and agreements from AERB.

Appendix 2: Format for certification of safety assurance and undertaking

This is to certify that all information of safety significance pertaining to the plant operations during the PSR period has been presented in the report and required safety assessment has been carried out. In the opinion of the plant management, the NPP/facility can be safely operated till the next PSR, without any undue risk to the plant, plant personnel, public and environment.

I undertake to:

1. Fulfil all the conditions and requirements stipulated in the operating license.
2. Keep AERB informed of any changes in the information furnished above.
3. Abide by the instructions/ directions of AERB.

Date: _____ Signature of Head of the Nuclear Power Plant/Facility

Fig. 1 – Overall Programme of PSR

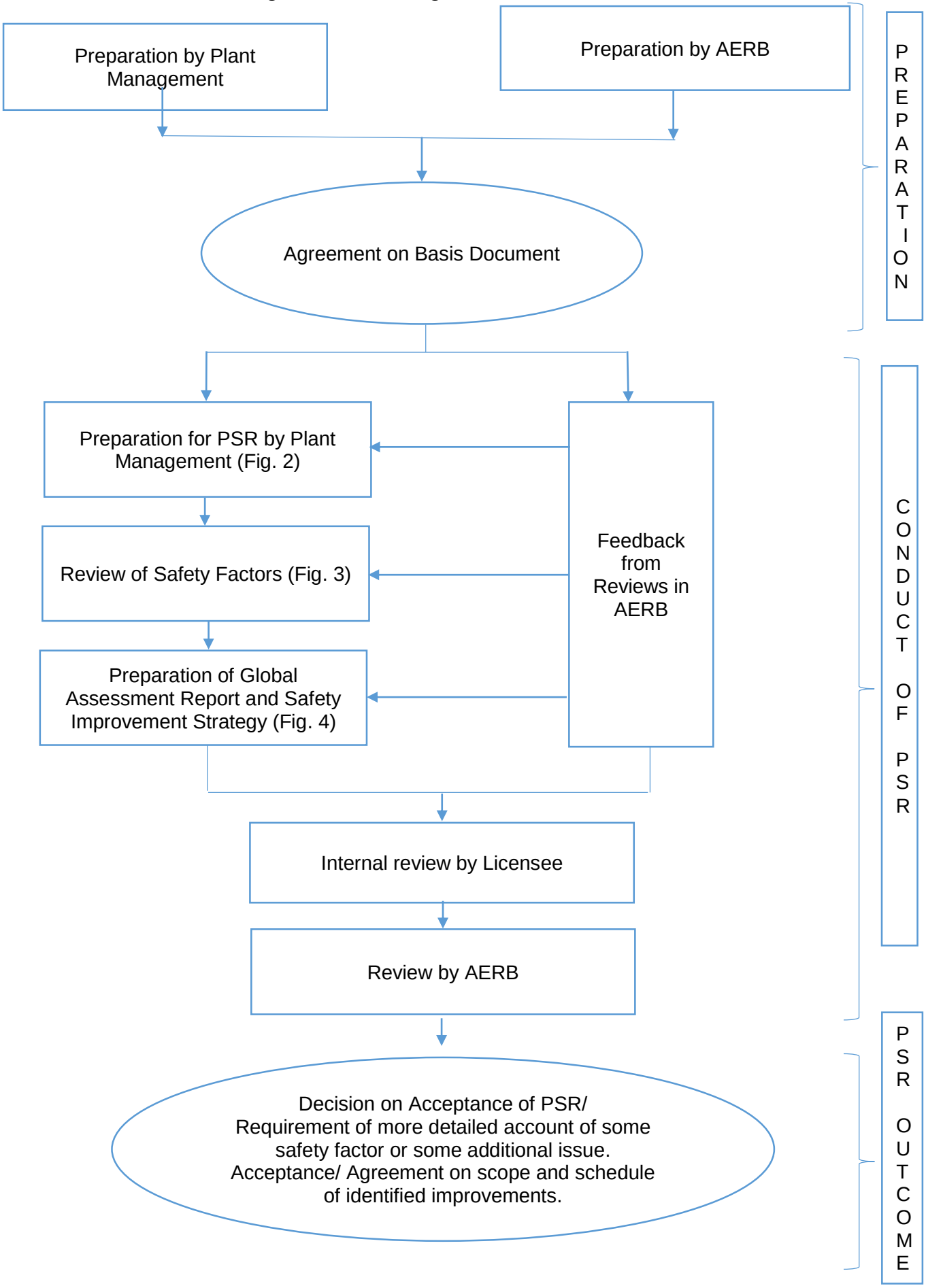


Fig. 2 – Activities of PSR by Plant Management

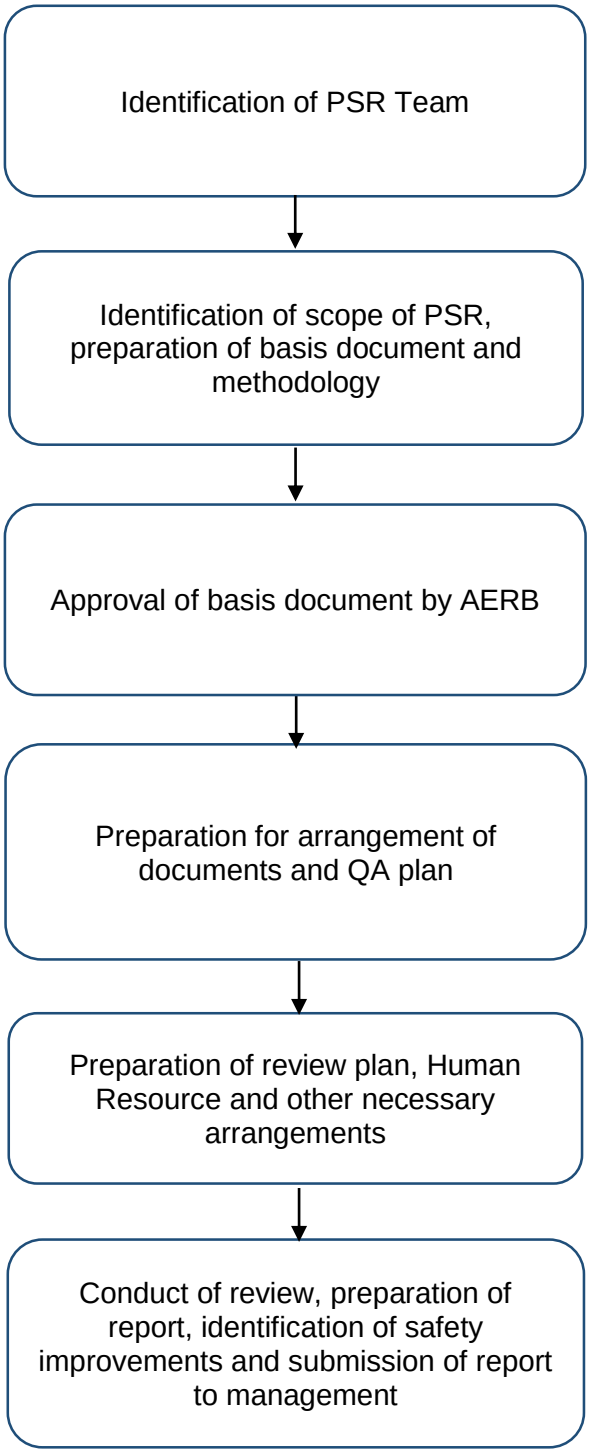


Fig. 3 – Process for Review of Safety Factors

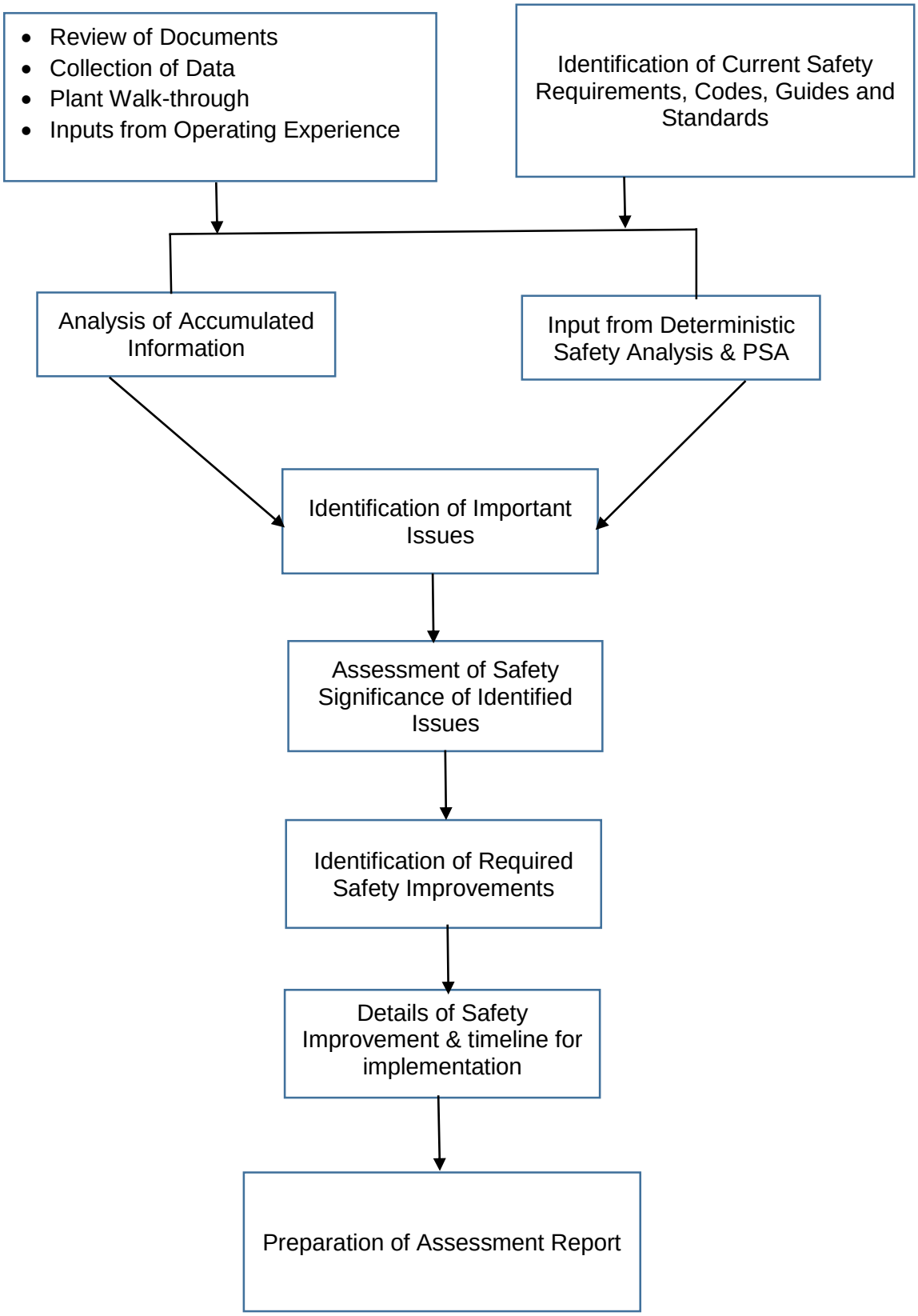
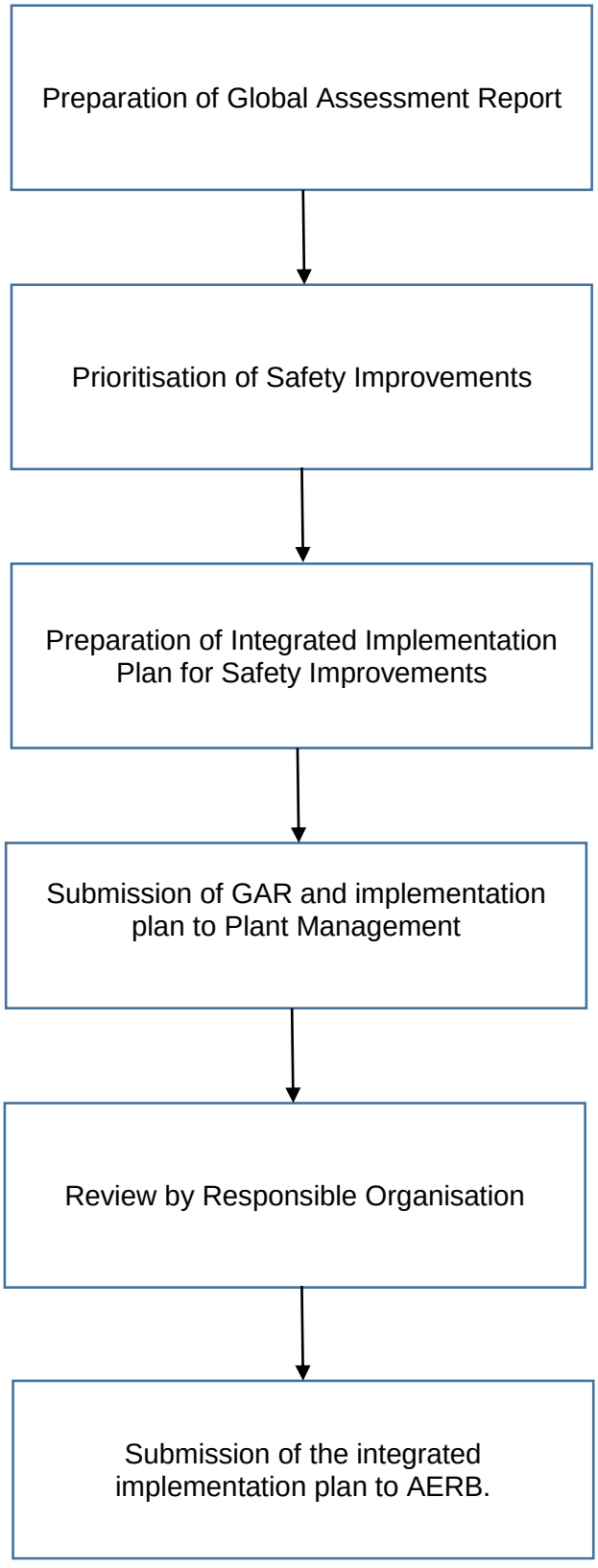


Fig. 4 – Global Assessment and Integrated Plan for Safety Improvement



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LIST OF PARTICIPANTS

IN-HOUSE WORKING GROUP (AERB-IHWG/O-12)

Shri Suneet Kavimandan, OPSD	-	Convener
Shri Diptojyoti Bhattacharya, OPSD	-	Member
Shri Anup Prabhakaran, OPSD	-	Member
Shri Parikshat Bansal, RDD	-	Member
Shri Devendra Upadhyay, OPSD	-	Member
Ms. Poorva Kaushik, OPSD	-	Member
Shri Ritu Raj, DRP&E	-	Member
Ms. Monalisha Nayak, OPSD	-	Member-Secretary

ADVISORY COMMITTEE FOR NUCLEAR AND RADIOLOGICAL SAFETY (ACNRS)

ACNRS Mtg. No. 14 held on February 09, 2019
ACNRS Mtg. No. 24 held on March 5, 2021
ACNRS Mtg. No. 26 held on December 17, 2021

MEMBERS OF ACNRS

Shri S.S.Bajaj, Former Chairman, AERB	-	Chairman
Shri C.S.Varghese, Executive Director, AERB	-	Member
Shri D.K.Shukla, Former Chairman, SARCOP, AERB	-	Member
Dr. M.R.Iyer, Former Head, RSSD, BARC	-	Member
Prof. C.V.R.Murty, Dept. of Civil Engg, IIT, Chennai	-	Member
Shri S.C.Chetal, Former Director, IGCAR	-	Member
Shri H.S.Kushwaha, Former Dir(HS&E Grp.), BARC	-	Member
Shri S.K.Ghosh, Former Dir (Ch. Engg. Grp.), BARC	-	Member
Shri K. K. Vaze, Former Dir (RD&D Group), BARC	-	Member
Dr. N.Ramamoorthy, Former CE, BRIT & AD, BARC	-	Member
Shri A. R. Sundararajan, Former Dir (RSD), AERB	-	Member
Shri Atul Bhandarkar, Director (T), NPCIL	-	Member
Shri Sanjay Kumar, Director (T-LWR), NPCIL	-	Member
Dr. A. N. Nandakumar, Former Head, RSD, AERB	-	Member
Shri A Jyothish Kumar, Director (O), BHAVINI	-	Member
Shri H.Ansari, Head, RDS, R&DD, AERB	-	Mem-Secy

EXPERTS and STAKEHOLDERS

Shri S. K. Chande, Ex Vice Chairman, AERB
Shri P. R. Krishnamurthy, Ex Director, OPSD
Shri Ashok Bhatia, NPCIL
Shri V. K. Sharma, NPCIL
Shri R. G. Godbole, NPCIL
Shri R. K. Agnani, NPCIL
Shri M. Venkatachalam, NPCIL

TECHNICAL EDITING AND COPY EDITING

Shri P.S.Virdi, AERB
Ms. Sonal Gandhi, AERB

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