NATIONAL NUCLEAR REGULATOR

For the protection of persons, property and the environment against nuclear damage

INTERIM REGULATORY GUIDE

PERIODIC SAFETY REVIEW OF NUCLEAR POWER PLANTS

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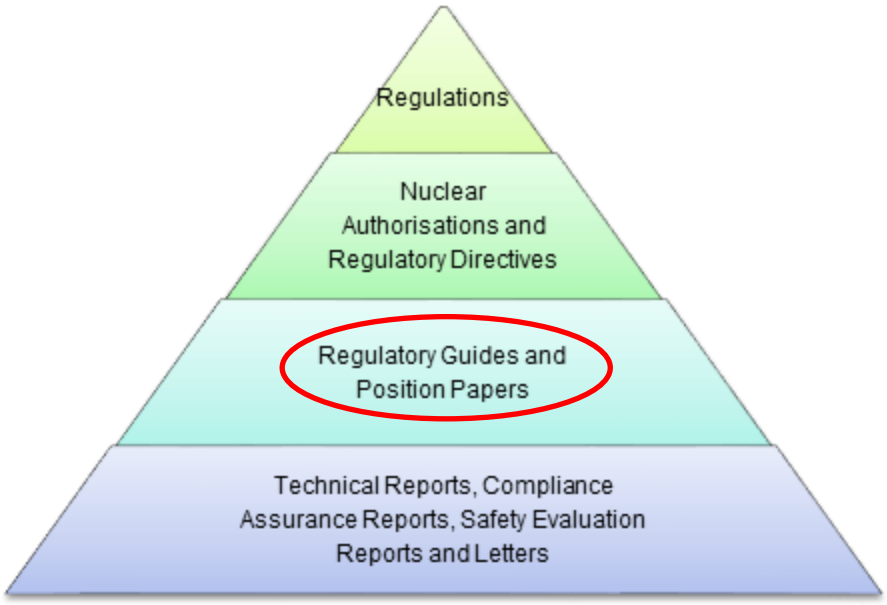

Figure 1: Location of the Regulatory Guide in the NNR Document Hierarchy

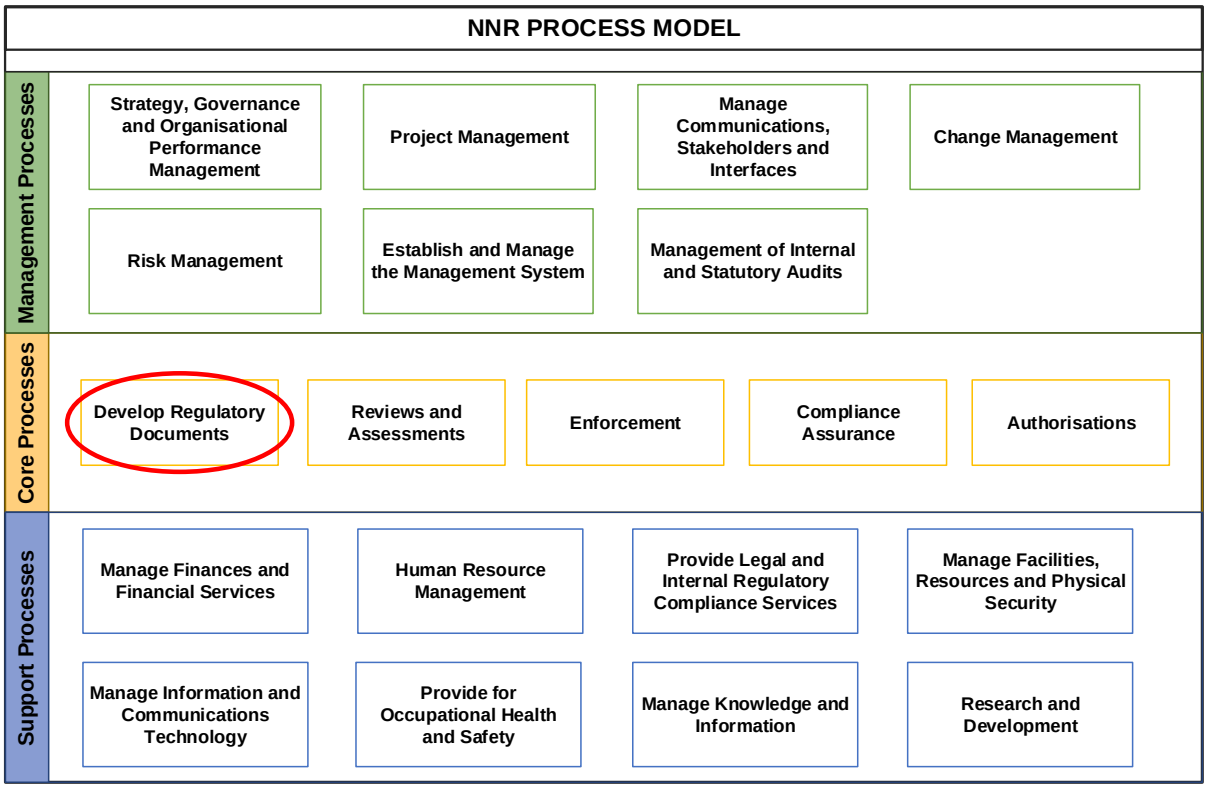

Figure 2: Location of the Regulatory Guide in the Process Model

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FOREWORD

The legal framework applicable to regulation of nuclear industry in South Africa is comprised of law and supporting regulatory documents. Law includes legally enforceable instruments such as Acts, regulations and conditions of licences. Regulatory documents comprise of policies, standards, guides, notices, procedures and information documents which support and provide further information on the legally enforceable instruments. Both law and regulatory documents form the framework for regulation of the nuclear industry in South Africa.

Regulatory Guidance documents provide guidance to the licensees and applicants on how to meet requirements of the legally enforceable instruments. This Regulatory Guidance document provides more information about approaches used by National Nuclear Regulator for the periodic safety review of nuclear power plants.

1 INTRODUCTION

The National Nuclear Regulator Act, 1999 (Act No. 47 of 1999) [1], hereafter referred to as the Act, establishes the National Nuclear Regulator (NNR) as an independent regulator and the competent authority for nuclear regulation in South Africa to provide for the protection of persons, property and the environment against nuclear damage.

Section 5 of the Act provides for the objects of the Regulator. In pursuit of these objects, the NNR has established safety standards and regulatory practices that have been documented as regulations and guidance documents. Regulations are mandatory and set specific requirements to be fulfilled by authorisation holders and applicants for nuclear authorisations. Guidance documents are developed to assist authorisation holders and/or applicants for authorisations in meeting the regulatory requirements.

The NNR ensures that its regulatory standards and practices are in line with best international standards and practices that are applied by nuclear regulatory authorities. Therefore, this guidance document was developed in accordance with international requirements and best practices and is based on the International Atomic Energy Agency's (IAEA) Safety Standards.

2 PURPOSE

This document provides guidance on the conduct of a periodic safety review for a nuclear power plant (NPP).

3 SCOPE

This guide is applicable to the conduct of a periodic safety review for an NPP.

4 DEFINITIONS AND ABBREVIATIONS

4.1 Definitions

ageing: General process in which characteristics of a structure, system or component gradually change with time or use.

ageing management: Engineering, operations and maintenance actions to control within acceptable limits the ageing degradation of structures, systems and components (SSCs).

authorisation holder: A holder of a nuclear authorisation as defined in the Act.

configuration management: The process of identifying and documenting the characteristics of a facility's SSCs (including computer systems and software), and of ensuring that changes to these characteristics are properly developed, assessed, approved, issued, implemented, verified, recorded and incorporated into the facility documentation.

current licensing basis: The safety case applicable at any time during operation of the plant, comprising applicable regulations and Regulator guidelines and all licence-binding documentation, including project management documentation, safety analysis report, operational limits and conditions, and other safety related programmes applicable during a licensing stage applicable during licensing stages (including modifications), which shall be retained as records.

design basis: The range of conditions and events taken explicitly into account in the design of a facility, according to established criteria, such that the facility can withstand them without exceeding authorised limits by the planned operation of safety systems.

design life: The period of time during which a facility or component is expected to perform according to the technical specifications to which it was produced.

in-service inspection: Inspection of SSCs undertaken over the operating lifetime by or on behalf of the operating organisation for the purpose of identifying age-related degradation or conditions that, if not addressed, might lead to the failure of structures, systems or components.

long term operation: The operation of a nuclear power plant beyond an established time frame set forth by, for example, the licence term, design, standards, licence and/or regulations, which has been justified by the safety assessment, with consideration given to life limiting processes and features of SSCs.

maintenance: The organised activity, both administrative and technical, of keeping SSCs in good operating condition, including both preventive and corrective (or repair) aspects.

nuclear licence: A legal document issued by the Regulator granting authorisation to perform specified activities related to a nuclear facility.

operating lifetime: The period during which an authorised facility is used for its intended purpose, until decommissioning or closure.

periodic safety review (PSR): 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).

safety factors: The important aspects of safety of an operating nuclear power plant.

safety related programmes: Collectively refers to all important to nuclear safety related activities conducted during the operational phase of the facility and may also be applicable during interim authorisation stages.

4.2 Abbreviations

EXCO	Executive Committee
IAEA	International Atomic Energy Agency
INPO	Institute of Nuclear Power Operations
IRS	International Reporting System for Operating Experience
KQMS	Knowledge and Quality Management Specialist
NEA	Nuclear Energy Agency
NNR	National Nuclear Regulator
NPP	Nuclear Power Plant
OECD	Organisation for Economic Co-operation and Development
PSA	Probabilistic Safety Assessment
PSR	Periodic Safety Review
QC	Quality Control
RITS	Regulatory Improvement and Technical Services

SSCs	Structures, systems and components
WANO	World Association of Nuclear Operators

5 REGULATORY FRAMEWORK

5.1 NNR Act

1) The legal basis for the NNR relating to the operation of nuclear facilities is derived from the NNR Act, specifically sections 5(b), 20(1), 21(1) and 23.

2) Section 5(b) of the Act grants the NNR the power to exercise regulatory control over the safety of siting, design, construction, operation, manufacture of component parts, and decontamination, decommissioning and closure of nuclear installations through the issuing of nuclear authorisations.

3) Section 20(1) of the Act states that no person may site, construct, operate, decontaminate or decommission a nuclear installation, except under the authority of a nuclear installation licence. In terms of the provisions of this section, the siting, construction, operation, decontamination or decommissioning of any nuclear installation as defined in section 1(xviii) of the Act must be authorised by way of a nuclear licence granted by the NNR.

4) Section 21(1) requires that any person wishing to site, construct, operate, decontaminate or decommission a nuclear facility may apply in the prescribed format to the Chief Executive Officer of the NNR for a nuclear licence and must furnish such information as the NNR board of directors requires.

5.2 Safety Standards and Regulatory Practices

1) Regulations on Safety Standards and Regulatory Practices [2], promulgated in terms of section 36 of the Act, include the following requirements relevant to periodic safety reviews that must be complied with:
   a) Requirement 4.1.1: Operational safety assessments must be made and submitted to the Regulator at intervals specified in the nuclear authorisation and which must be commensurate with the nature of the operation and the radiation risks involved.

b) Requirement 4.1.2: Operational safety assessments must be of sufficient scope and must be conducted and maintained in order to demonstrate continuing compliance with the dose, risk limits and other relevant conditions of the nuclear authorisation.
c) Requirement 4.1.3: The operational safety assessment must establish the basis for all the operational safety related programmes, limitations and design requirements.

6 PERIODIC SAFETY REVIEW

6.1 General Guidance

The periodic safety review should cover all facilities and SSCs on the site covered by the operating licence (including waste management facilities, on-site simulators, etc.) and their operation, together with the authorisation holder and its staff. The PSR should be performed at the interval as specified in the nuclear authorisation, which is normally every ten years.

1) When performing the PSR of a nuclear power plant with several units:
   a) Aspects such as radiation protection, emergency planning and radiological impact on the environment can be covered in reviews that are common to all units; and
   b) Other aspects (for example, the actual condition of SSCs important to safety, ageing and safety performance) should be covered in reviews that are specific to each unit.

2) Before the review work is started, NNR acceptance and/or confirmation should be obtained on the scope and objectives of the PSR, including the current national and international standards and codes to be used. This is documented in the basis document for the PSR, which should be developed by the authorisation holder and made subject to acceptance and/or confirmation by the NNR.

3) The PSR basis document governs the conduct of the PSR and the regulatory review of the PSR results. The typical content of a PSR basis document is presented in Annexure C.

4) The PSR should apply all relevant national safety regulations and standards. Other requirements such as international safety standards and operating practices, and national or international guides should be met to the fullest extent practicable. The selection and hierarchy of safety standards and operating practices considered should be clearly stated

in the PSR basis document. Special consideration should be given to safety standards issued by the country of origin of the technology.

5) If there are no adequate national standards, reference should be made to international codes and standards (such as those of the IAEA, the International Organization for Standardization and the International Electrotechnical Commission) or, where appropriate, to codes and standards of a recognised organisation (for example, ASME, the Nuclear Safety Standards Commission, or).

6) The practices of international organisations, such as good practices collected by the World Association of Nuclear Operators (WANO) and the IAEA as well as the information generated by owners' groups, could also be relevant and should be taken into account where possible.

7) The PSR basis document should outline or reference the project management and management system processes to be followed in carrying out the PSR so as to ensure a complete, comprehensive, consistent and systematic approach. The processes used to conduct the PSR and to produce the various documents relating to the review should comply with the requirements of RD-0034 or, where appropriate, international standards.

8) The PSR basis document should provide or reference a project plan that identifies all the activities to be performed during the review, together with associated timelines and responsibilities. This should present a realistic and reasonable schedule for the conduct of the PSR, including sufficient allowance for the completion of reviews by the NNR. The allowance should take into consideration the minimum 12-month NNR review period as well as the time required to resolve any disputes and to agree on findings and improvement measures. These activities must be completed before the next period commences. The typical content of a PSR project plan is presented in Annexure C.

9) The schedule should take into account that the review of safety factors is an iterative process and that the interface between safety factors also needs to be taken into account. Teams reviewing different safety factors should communicate with each other throughout the review process, starting in the preparation phase. Some of the findings identified in the review of a particular safety factor may need to be considered in the review of other safety factors. The outputs from the review of some safety factors may be relevant as inputs to

the review of other safety factors. Typical lists of input and output information for each safety factor are provided in Annexure D.

10) The starting point for the PSR should be taken to be the time of the NNR's acceptance and/or confirmation in the preparation phase. The end point of the PSR will be the NNR's acceptance and/or confirmation of the integrated implementation plan.

11) The second (or subsequent) PSR of a nuclear power plant should focus on changes in requirements, plant conditions, operating experience and new information, rather than repeating the activities of previous reviews. However, a subsequent PSR should consider explicitly whether the earlier PSR continues to remain valid (for example, in light of the time elapsed since it was performed).

12) The PSR should take account of existing ongoing processes, such as configuration management and ageing management, and the results of and/or trend analyses from these processes should be reviewed to evaluate their effectiveness.

13) The PSR should consider how effective the plant's configuration management programme has been in keeping the safety documentation (for example, the final safety analysis report) up to date in light of subsequent modifications, refurbishment and changes to operating, testing, maintenance and other practices.

14) The safety factors should be reviewed for all relevant plant states as well as operating and accident conditions, using current national and applicable international safety standards and operating practices as identified in the PSR basis document.

15) Some safety factors or parts of a safety factor might be assessed more efficiently and effectively in other contexts or through different means than by the PSR (for example by continuous review through other programmes). In such cases, the PSR should focus on the assessment methodology applied at the nuclear power plant and should review relevant trends.

16) As part of the review of each safety factor, all the documents listed in the PSR basis document should be checked for completeness. Where there is no overall technical database for the plant, it is reasonable to establish a common set of databases for the review of the 14 safety factors and the global assessment early in the review process.

17) Findings from the reviews of safety factors should be evaluated and the timing of any proposed safety improvements should be determined. The proposed plan should recognise the need to implement safety improvements as soon as reasonable and practicable in accordance with the global assessment of safety at the plant. Instances where there is an immediate and significant risk to the health and/or safety of workers or the public, or to the environment, should be addressed urgently by the authorisation holder and should not await completion of the PSR process. Instead, the authorisation holder should determine prompt corrective actions and, where relevant, submit these without delay to the NNR for approval.

18) The level of plant safety should be determined by a global assessment reflecting, among other things, the combined effects of all safety factors. It is possible that a negative finding (deviation) in one safety factor can be compensated for by a positive finding (strength) in another safety factor.

19) If the design basis for the nuclear power plant is not currently documented, the authorisation holder should re-establish the design basis early in the PSR process. Otherwise the PSR should review the design basis documentation using the final safety analysis report where this is part of the safety and/or licensing documentation.

20) The results of relevant studies, routine and special safety reviews, as well as activities relating to licensing, compliance or operations, should be used, as appropriate, as inputs into the PSR to minimise any duplication of effort. The origins of all information used should be referenced appropriately and an explanation should be provided of how each reference has been used.

21) Safety improvements should be implemented in accordance with the integrated implementation plan submitted to the NNR for acceptance and/or confirmation. For a PSR of plants with multiple units, safety improvements may be implemented in a lead unit and lessons learned may then be used for the implementation of safety improvements in the remainder of the units.

22) The global assessment should take into account all the positive and negative findings from the PSR, and the corrective actions and/or safety improvements proposed, and should

assess the overall level of safety that will be achieved at the nuclear power plant following the PSR. Where there are negative findings, the global assessment should provide a justification for any improvements that cannot reasonably and practicably be made.

23) The risks associated with any unresolved negative findings should be assessed. Section 6.4 provides further recommendations on the content of the global assessment, and on the prioritisation and categorisation of safety improvements.

24) The PSR results should be documented by the authorisation holder and the documentation should be submitted to the NNR either during the PSR or during a structured continuous improvement programme, as required. The documentation should include:
   a) Reports on the review of each safety factor;
   b) A report documenting the results of the global assessment; and
   c) The final PSR report, including information on the proposed safety improvements and integrated implementation plan and a summary of the reports on safety factors and the global assessment.
   d) The contents of these documents are described in Annexure C.

6.2 Review Process

1) The process outline for undertaking the PSR is shown in Annexure A. The process consists of parallel but independent activities of the authorisation holder and the NNR.

2) The activities of the authorisation holder can be divided into three steps:
   a) Preparation for the PSR project;
   b) Conduct of the reviews of safety factors; and
   c) Analysis of the findings (including the global assessment), and preparation of a programme of safety improvements.

3) The starting point of a PSR is the acceptance and/or confirmation by the NNR of the general scope and requirements for the PSR, and its expected outcome, as described in the basis document. As part of this acceptance and/or confirmation, the authorisation holder and the NNR 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.

6.2.1 PSR project preparation

1) An appropriate project management team should be established and a reasonable time schedule should be developed for the PSR project.

2) The schedule should take into account the iterative nature of the review of safety factors and should allow time for interfaces between the various safety factors to be dealt with.

3) A document should be prepared to provide guidance to the review teams on how to review the different safety factors so as to ensure a comprehensive, consistent and systematic approach. This guidance document should elaborate on the agreed general scope of the PSR. It should also identify applicable safety standards, methods and practices, which, in most cases, should be based on current national standards and practices and should reflect current knowledge. These standards, methods and practices should also be included in the PSR basis document.

4) A quality assurance plan should be prepared that, among other things, defines the requirements for the preparation and verification of the PSR documentation. The quality assurance plan should also ensure that all reviewers use the same input data to maintain consistency across all areas of the review.

6.2.2 Safety factor review

1) To improve overall efficiency and consistency, a common set of technical databases may be developed for use within the separate safety factor reviews. These databases should include operational data, complemented with the relevant design basis information and, if available, information from the final safety analysis report. These databases should also contain predictions of future operation and service lives of SSCs important to safety.

2) A review of each safety factor should be carried out for all relevant operational states and accident conditions, and an assessment for each safety factor should be made against current safety standards and operating practices (for example, using information from operating experience or plant walkdowns).

3) Areas where either the licensing basis or current standards and practices are not achieved should be identified. The safety significance of all findings should be evaluated using deterministic and probabilistic methods as appropriate. A list of proposed safety improvements (or, if no safety improvement can be identified that is reasonable and practicable, a justification for this) should be prepared for each negative finding.

4) If the authorisation holder 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, implementation of safety improvements should not await completion of the PSR; rather, prompt corrective actions should be taken.

5) Areas where current safety standards and practices are exceeded (that is, plant strengths) should be identified and stated in the safety factor reports.

6) A safety factor report should be prepared to summarise the results of the review of each safety factor (see Annexure C).

7) A global assessment should be performed and a report of the global assessment should be prepared (see Annexure C).

8) A final PSR report should be prepared to include the following:
   a) A summary of the outcomes from the safety factor reports, including a list of findings indicating areas where current standards and practices are not achieved, and a list of areas where current safety standards and practices are exceeded (that is, plant strengths);
   b) A summary of the outcomes from the global assessment; and
   c) An integrated implementation plan of proposed safety improvements, including their safety significance and prioritisation.

6.2.3 Preparation of the integrated implementation plan of safety improvements

1) The safety improvements and the integrated implementation plan proposed in the final PSR report should be updated after the final PSR report has been accepted by the NNR. The revised final PSR report should include the outcome of discussions regarding the

scope and adequacy of the proposals for safety improvements and applicable changes to their ranking, prioritisation and timing.

2) The integrated implementation plan should consider interactions between individual safety improvements, with consideration given to appropriate configuration management. The plan should also specify the schedules for implementation of safety improvements and the necessary resources. It is recognised that the implementation of safety improvements will have different execution times; however, it is expected that the majority of the safety improvements will be completed far in advance of the next PSR and all by the next PSR.

3) The integrated implementation plan should be submitted to the NNR for review in accordance with NNR safety standards.

4) A summary report should be prepared to present the highlights of the PSR process. This summary report could be shared with members of the public.

5) The authorisation holder should maintain adequate arrangements for project management after the completion of the PSR. These arrangements should ensure that the NNR is notified when safety improvements are implemented and of any significant delays in completing the improvements later than the agreed time schedule.

6) All PSR documentation should be stored using a suitable system to allow easy retrieval and examination. The documentation should contain the final versions of the PSR documents and information on lessons learned from the PSR.

7) The outcomes of the PSR and the resulting safety improvements will often necessitate changes to plant documentation. Therefore, the authorisation holder should update all plant documentation including, for example, the safety analysis report, operating and maintenance procedures and training materials, to reflect the outcomes of the PSR.

8) Similarly, the PSR and the implementation of safety improvements will often result in the revision of design, operation and licensing documentation to reflect the actual configuration of the nuclear power plant. The authorisation holder should modify all affected documentation (for example, manuals relating to the authorisation holder, the emergency plan and training plans) as necessary.

9) The safety analysis report should be updated after completion of the PSR to reflect the results of reviews of reference documents and requirements and to take account of the new operating experience. The final safety analysis report (or other equivalent safety documents) should be updated to incorporate all design changes completed and results of safety analyses obtained in support of the safety improvements.

6.3 Safety Factors

1) Fourteen safety factors are identified, which may be used to subdivide the PSR. These safety factors, their individual objectives, scope and tasks and also the specific methodology for their review are listed and explained in this section. Information on interfaces between safety factors is provided in Annexure B and information on typical inputs and outputs for each safety factor is given in Annexure D. The content of a typical report on the review of each safety factor is set out in Annexure C.

2) Radiation protection is normally not regarded as a separate safety factor. The arrangements for radiation protection and their effectiveness should generally be reviewed as specific aspects of the safety factors relating to: plant design; actual condition of SSCs important to nuclear safety; safety performance; and procedures. Alternatively, radiation protection may be reviewed as a separate safety factor.

3) Findings from the review of individual safety factors may indicate that plant safety is acceptable; however, a global assessment of safety at the plant should be carried out to review interactions, overlaps and gaps between safety factors and to form an overall view.

4) The review of safety factors should determine the status of each safety factor at the time of the PSR and should assess future safety at the nuclear power plant at least until the next PSR and, where appropriate, up to the end of planned operation. This should include a review of the capability of the authorisation holder to identify potential failures and either prevent them or mitigate their consequences before they could lead to a radiological incident. Ageing related degradation mechanisms that could lead to failures of SSCs important to nuclear safety that could potentially limit the plant's operating lifetime should be identified to the extent possible.

5) The level of detail of the review could vary from safety factor to safety factor. For some safety factors, a high level or programmatic review could be performed. Where such an approach is adopted, this should be set out and justified in the PSR basis document.

6) The review of safety factors should assess all relevant documents identified in the PSR basis document. If further documents are identified as being relevant during the PSR process, these should be reviewed too.

7) The outputs from the review of safety factor 9 relating to the use of experience from other plants and research findings, together with feedback of operating experience at the plant itself (addressed under safety factor 8 on safety performance), can be used as early inputs to the reviews of other safety factors. Therefore, the majority of the tasks in the review of these safety factors should be addressed at an early stage in the PSR.

8) Prior to commencing the review of the various safety factors, methods to assess, categorise, rank and prioritise findings should be established and these methods should be documented.

9) The review of safety factors will identify positive and negative findings, which should be documented in the safety factor review report. If there are no changes in relevant safety standards or to the plant, a statement to this effect should be made in the report.

10) Negative findings should be divided into:
    a) Deviations for which no reasonable and practicable improvements can be identified;
    b) Deviations for which identified improvements are not considered necessary; and
    c) Deviations for which safety improvements are considered necessary.

11) The approach taken to negative findings should be justified by the authorisation holder and acceptance and/or confirmation by the NNR should be sought.

12) In the case of negative findings 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 negative findings for which safety improvement are not considered necessary, the reason(s) should be documented and the action considered completed. Negative findings

for which safety improvements are necessary, including updating/or extending of plant documentation or operating procedures, should be categorised and prioritised according to their safety significance. The categorisation and prioritisation 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 authorisation holder's integrated implementation plan.

13) If the team reviewing a safety factor 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, corrective action should not await the completion of the PSR. Rather, the authorisation holder should take urgent steps to reduce the immediate and significant risk and, where relevant, should submit details of these steps to the NNR for approval.

14) Findings that have an interface with other safety factors should be discussed immediately with the relevant review team(s).

6.4 Global Assessment

1) The objective of the PSR global assessment is to arrive at a judgement of the nuclear power plant's suitability for continued operation on the basis of a balanced view of the findings from the reviews of the separate safety factors. This judgement should take account of the safety improvements considered in the global assessment as necessary (which may relate to the plant, or to the authorisation holder) together with any positive findings (strengths) identified in the safety factor reviews. The global assessment should evaluate the impact on safety based on the findings from all the separate safety factors and so needs to be performed after completion of all the individual safety factor reviews.

2) The global assessment should highlight interface issues and should identify overlapping issues between the various safety factor reviews, thus ensuring that such issues are appropriately and fully addressed.

3) An analysis of the interfaces between the various safety factors (see Annexure B) should be carried out as part of the global assessment. The approach taken should use

appropriate general, high level categories consistent with the Fundamental Safety Principles of the IAEA.

4) The global assessment should examine supporting information such as documents on the scope and methodology of the PSR, regulatory requirements, feedback from the NNR on previously submitted PSR documents, particular issues raised by the NNR and additional reference material.

5) The global assessment should be performed by an interdisciplinary team, with appropriate expertise in operation, design and safety at the plant, including an appropriate number of participants from the safety factor reviews. The team should also include members who are independent from the safety factor review teams.

6) The global assessment should consider all the findings (positive and negative) from the separate safety factor reviews and should consider what safety improvements are reasonable and practicable. The global assessment should also consider overlaps and omissions between the separate safety factors and so determine whether additional or grouped safety improvements arising from more than one safety factor review are also reasonable and practicable. Identified safety improvements judged not to be reasonable and practicable should not be pursued any further.

7) A method for assessing, categorising, ranking and prioritising safety improvements to address negative findings should be established prior to performing the global assessment. The method should be based on the safety significance of each proposed improvement and then applied to all the improvements proposed within the global assessment. The approach adopted could be based on deterministic analysis, probabilistic safety assessment (PSA), engineering judgement, cost benefit analysis and/or risk analysis or a combination thereof. The safety improvements proposed in the global assessment should be included in the integrated implementation plan.

8) The risks associated with negative findings should be assessed and an appropriate justification for continued operation should be provided. This justification should address operations both in the short term prior to the implementation of identified safety improvements and in the long term if the global assessment concludes that addressing some of the negative findings is not reasonable and practicable.

9) Although negative findings may be individually acceptable, their combined effects should also be reviewed for acceptability. This is particularly relevant when considering human and organisational factors. It is also possible that a weakness in one safety factor can be compensated for by a strength in another. For example, it may be acceptable on a temporary or permanent basis to use a strength in human factors (such as operator action supported by adequate procedures) to compensate for a weakness in design or equipment (such as a lack of automatic protection against a postulated slow type of reactor fault of very low probability).

10) As part of the global assessment, the following should be examined:
    a) The time necessary for implementing corrective actions and/or safety improvements. 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). Alternatively, depending on the safety significance of the safety improvement and the remaining planned lifetime of the plant, adequate interim measures could be implemented. If a modification is necessary on the grounds of unacceptable risk, then relevant operations should be halted until after the modification has been implemented or adequate interim measures implemented and, where required by regulations, approved by the NNR.
    b) The use of PSA to estimate the risk posed by a negative finding. Such estimates should be provided in the review for the PSA safety factor (safety factor 6). However, while PSA can provide useful insights into relative risks, help judge priorities and compare options, a decision-making process that is solely based on numerical risks is not appropriately robust or reliable and so should not be adopted.
    c) The total effect of the negative findings, safety improvements and positive findings (strengths) identified in the PSR should be examined using deterministic methods to ensure that the overall level of plant safety is adequate.

11) The global assessment should review the extent to which safety requirements relating to the concept of defence in depth and the fundamental safety functions (reactivity control, core cooling and the confinement of radioactive material) are fulfilled. The adequacy of the plant's defence in depth may be demonstrated by reference to the five levels defined in INSAG-10 [14].

12) Overall conclusions and safety improvements considered to be reasonable and practicable in accordance with the global assessment should be documented in the final PSR report (see Annexure C). The safety improvements should be included in the integrated implementation plan and then implemented according to a time schedule agreed with the NNR.

7 LONG TERM OPERATION

1) The PSR should be used to support the decision-making process prior to entering long term operation, and any necessary safety improvements to ensure that the licensing basis remains valid during the period of long term operation should be specifically identified. Such improvements might include refurbishment, the provision of additional SSCs and/or additional safety analysis and engineering justifications.

2) The scope of the review of the safety factors should be adapted to determine the feasibility of long term operation. For example, the scope of the safety factor relating to ageing should be expanded to include an evaluation of the safety analyses with time limited assumptions and assessments of ageing effects. In the review, increased importance should be given to ageing mechanisms and ageing management programmes.

3) The PSR used to support long term operation should consider the entire planned period of long term operation, and not just the ten years until the next PSR. Furthermore, if long term operation is approved, PSR should continue to be performed in a ten-year cycle or at a frequency as required by the NNR.

4) The PSR used to support long term operation should pay particular attention to the following safety related programmes and documentation, as these are of significant importance for continued safe operation:
   a) Safety related programmes to support the safety factors relating to plant design, the actual condition of SSCs important to safety, equipment qualification and ageing;
   b) A management system that addresses quality management and configuration management;
   c) Safety analyses involving time limiting assumptions relating to the proposed lifetime; and

d) Programmes for promoting safety culture focused on the pursuit of excellence in all aspects of safety management and human factors.

5) Detailed guidance on ageing management and long term operation for NPPs is provided in RG-0027 [4].

8 REFERENCES

The following references were consulted during the compilation of this document:

[1] National Nuclear Regulator Act, 1999, (Act No. 47 of 1999).
[2] Regulations on Safety Standards and Regulatory Practices (No. R.388).
[3] RD-0034, Quality and Safety Management Requirements for Nuclear Installations.
[4] RG-0027, Interim Regulatory Guide on Ageing Management and Long Term Operations of Nuclear Power Plants.
[5] IAEA Specific Safety Guide No. SSG-25, Periodic Safety Review for Nuclear Power Plants.
[6] IAEA Specific Safety Guide No. SSG-40, Predisposal Management of Radioactive Waste from Nuclear Power Plants and Research Reactors.
[7] IAEA Specific Safety Guide No. SSG-50, Operating Experience Feedback for Nuclear Installations.
[8] IAEA General Safety Guide No. GSG-7, Occupational Radiation Protection.
[9] IAEA Specific Safety Requirements No. SSR-2/1, Safety of Nuclear Power Plants: Design.
[10] IAEA Specific Safety Requirements No. SSR-2/2, Safety of Nuclear Power Plants: Commissioning and Operation.
[11] IAEA Safety Guide No. NS-G-1.13, Radiation Protection Aspects of Design for Nuclear Power Plants.
[12] IAEA Safety Guide No. NS-G-2.2, Operational Limits and Conditions and Operating Procedures for Nuclear Power Plants.
[13] IAEA Safety Guide No. NS-G-3.2, Dispersion of Radioactive Material in Air and Water and Consideration of Population Distribution in Site Evaluation for Nuclear Power Plants.
[14] IAEA INSAG-10, Defence in Depth in Nuclear Safety.

ANNEXURE A: PSR PROCESS

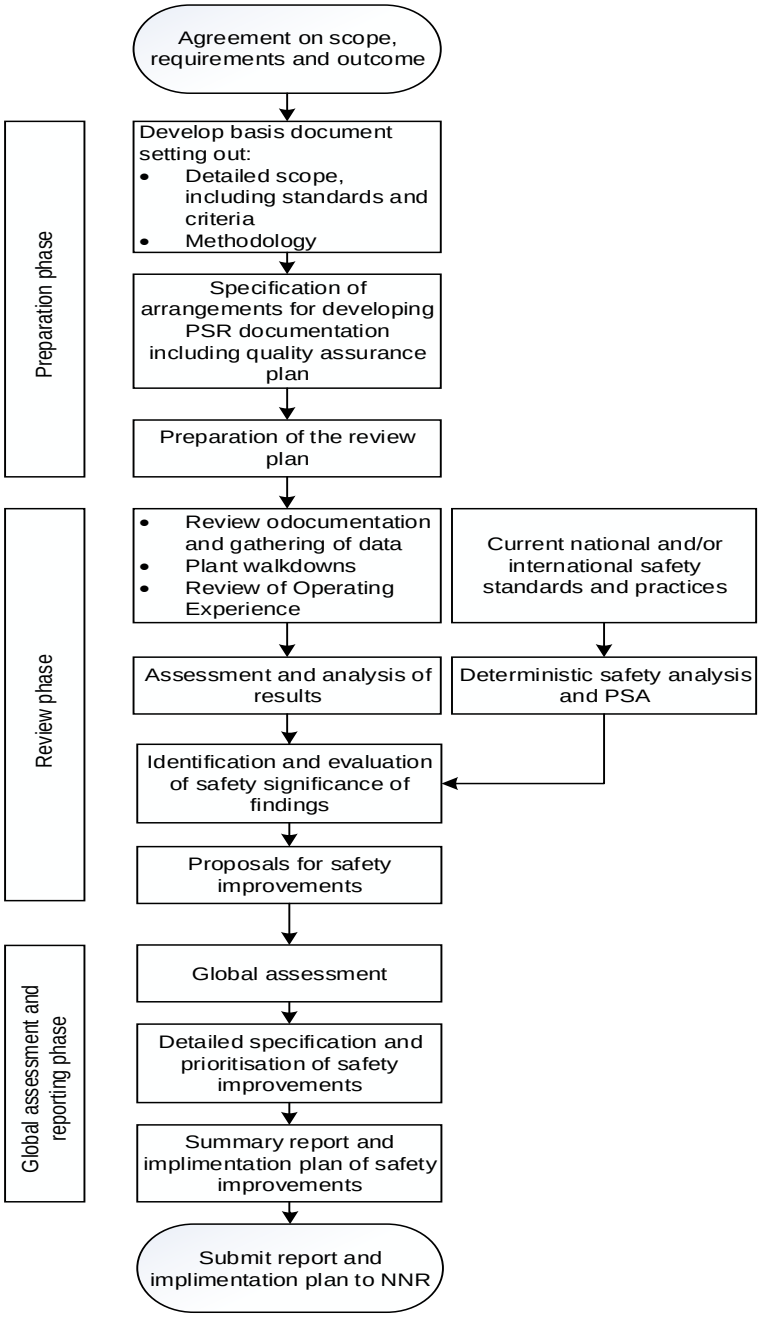

Figure 3: PSR process

ANNEXURE B: LINK BETWEEN SAFETY FACTORS

Starting from the preparation phase of the PSR, the teams reviewing each safety factor should communicate with each other during the review process. Communication between review teams should be well organised as findings (or outputs) identified in the review of one safety factor could be important as inputs to the review of other safety factors.

Potential likely correlations between the different safety factors are shown in the figure below. The safety factors listed on the horizontal axis may provide input to the safety factors listed on the vertical axis.

		Safety factors (SF) providing input													
		SF1	SF2	SF3	SF4	SF5	SF6	SF7	SF8	SF9	SF10	SF11	SF12	SF13	SF14
Safety factors (SF) receiving input	SF1		X	X	X	X	X	X	X	X			X	X	X
	SF2	X		X	X	X			X	X	X				
	SF3	X	X		X	X	X	X	X	X	X			X	
	SF4	X	X	X		X	X	X	X	X	X	X			
	SF5	X	X	X	X		X		X	X		X	X	X	
	SF6	X	X	X	X	X		X	X	X		X	X	X	
	SF7	X	X	X		X	X		X	X		X	X	X	X
	SF8	X	X			X	X	X		X	X	X	X		X
	SF9	X									X	X			X
	SF10		X			X	X		X	X		X	X		X
	SF11	X	X	X	X	X	X	X	X	X	X		X	X	X
	SF12	X	X	X	X	X	X	X	X	X	X	X			
	SF13	X				X	X	X	X	X		X			
	SF14	X	X				X		X	X		X			

Figure 4: Safety factor correlations

ANNEXURE C: PSR DOCUMENTATION

The documents that should be produced during the conduct of the PSR are specified below.

1) PSR basis document

The PSR basis document should include three main parts:

a) General

- The scope and objectives of the PSR and the future operating period that will be considered by 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 licensing basis at the time of initiating the PSR;
- Relevant regulatory requirements;
- The list of safety factors to be reviewed within the PSR and interfaces between them;
- A description of the systematic review approach to be used to ensure a complete and comprehensive review;
- Processes for identifying, categorising, prioritising and resolving negative findings;
- 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;
- The methodology to be used for the global assessment and the planned document structure of the global assessment report;
- Guidance for preparation of the integrated implementation plan of safety improvements; and
- The systematic method to be used for recording outputs from the PSR, including the proposed formats of:
    - The safety factor reports;
    - The global assessment report; and
    - The final PSR report, including the integrated implementation plan of safety improvements.

b) 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; and
- Expected outputs.

c) Project plan for the PSR

- Organisation 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; and
- The plan for communicating and interfacing with and gaining relevant approvals and acceptance and/or confirmation from the NNR.

2) Safety factor report

The safety factor report should include the results from the review of each safety factor following the approach detailed in the PSR basis document. The findings specific to each safety factor should be documented and ranked according to their safety significance. The findings on all safety factors are included in a single report; however, multiple reports can be developed. If multiple reports are to be developed, a general template or structure should be provided to maintain consistency and to ensure that all the items required to be reviewed are covered by the different teams performing the PSR.

The following is an example of the structure of a typical safety factor report:

- Title (name of the safety factor);
- Introduction;
- Scope of the review, including a list of the documents and aspects of safety reviewed;

- Review criteria (reference standards, operating practices, safety assessment criteria, etc.);
- Review methodologies applied;
- Review of performance since the previous PSR;
- Comparison with review criteria and discussion of the results;
- Evaluation of the safety significance of negative findings, together with proposed safety improvements and their prioritisation;
- Review of future safety for the period addressed in the PSR;
- Conclusions;
- References; and
- Appendices.

3) Global assessment report

The PSR results for all safety factors should be evaluated through a global assessment, and the following items should be documented:

- Significant PSR outcomes, including positive and negative findings (strengths and deviations);
- Analysis of interfaces, overlaps and omissions between safety factors and between individual negative findings;
- An overall analysis of the combined effects of the positive and negative findings;
- The category, ranking and priority of safety improvements proposed to address negative findings;
- An assessment of defence in depth;
- An assessment of the overall risk; and
- Justification for proposed continued operation in both the short term and long term.

4) Final PSR report

The final PSR report should provide an overview of the PSR and should include the following topics:

- Summary of the outcomes of the safety factor reports;
- Summary of the outcomes of the global assessment report, including:

  - Identification of negative findings arising from deviations between the present state of the plant and current safety standards and operational practices;
  - An evaluation of the safety significance of these negative findings;
  - An overall judgement on the acceptability of continued plant operation;
- The integrated implementation plan, including proposals for resolving negative findings by safety improvements or corrective actions, and their safety significance and priority; and
- An assessment of the safety of future plant operation over the period addressed in the PSR.

ANNEXURE D: REVIEW OF SAFETY FACTORS

Safety Factor 1: Plant Design

Plant SSCs important to safety should be appropriately designed and configured in such a way that there is a high degree of confidence that they will meet the requirements for safe operation of the plant and for performance in compliance with design characteristics, including the prevention and mitigation of events that could jeopardise safety (i.e. fulfilment of their safety functions). Adequate design information, including information on the design basis, should be made available to provide for the safe operation and maintenance of the plant and to facilitate plant modifications.

Objective

The objective of the review of plant design is to determine the adequacy of the design of the nuclear power plant and its documentation by assessment against the current licensing basis and national and international standards, requirements and practices.

Scope and tasks

The review of plant design (including site characteristics) should include the following tasks:

- Review of the list of SSCs important to safety for completeness and adequacy.
- Review to verify that design and other characteristics are appropriate to meet the requirements for plant safety and performance for all plant conditions and the applicable period of operation, including:
  - The prevention and mitigation of events (faults and hazards) that could jeopardise safety;
  - The application of defence in depth and engineered barriers for preventing the dispersion of radioactive material (integrity of fuel, cooling circuit and containment building);
  - Safety requirements (for example, on the dependability, robustness and capability of SSCs important to safety); and
  - Design codes and standards.

- Identification of differences between standards met by the nuclear power plant's design (for example, the standards and criteria in force when it was built) and modern nuclear safety and design standards.
- Review of the adequacy of the design basis documentation.
- Review for compliance with plant design specifications.
- Review of the safety analysis report or licensing basis documents following plant modifications and in light of their cumulative effects and updates to the site characterisation.
- Review of plant SSCs important to safety to ensure that they have appropriate design characteristics and are arranged and segregated in such a way as to meet modern requirements for plant safety and performance, including the prevention and mitigation of events that could jeopardise safety.
- Review of the strategy for the spent fuel storage and conduct of an engineering assessment of the condition of the storage facilities, the records management and the inspection regimes being used.

The scope of this review will depend on the extent of changes in standards and/or the licensing basis since the previous PSR or the start of operation.

Methodology

The review should be performed systematically by means of a clause-by-clause review of national and international requirements and standards listed in the PSR basis document and other requirements and standards identified as relevant during the course of the review. Where this would assist the review, the evolution of these requirements and standards from the versions used for the original design should be evaluated to assess the impact of changes on the plant design.

In the review, consideration should be given to subdivision into topics according to plant systems, such as reactor core, reactor coolant system, containment system, instrumentation and control systems, electrical power systems and auxiliary systems.

In some cases, comparison with requirements and standards may be best carried out by means of a high level or programmatic review. If this approach is to be adopted, the PSR basis

document should clearly indicate this intention and, where appropriate, this should be agreed with the NNR.

The review of this safety factor should be carried out for all SSCs important to safety. The review should seek to identify deviations between the plant design and current safety requirements and standards (including relevant design codes) and to determine their safety significance. If a suitable list of SSCs is not available, one should be developed by the authorisation holder as part of the PSR.

The review should consider the adequacy of defence in depth in the plant design. This should include an examination of:

- The degree of independence of the levels of defence in depth;
- The adequacy of delivery of preventive and mitigatory safety functions;
- Redundancy, separation and diversity of SSCs important to safety; and
- Defence in depth in the design of structures (for example, review of the integrity of fuel, cooling circuit and containment building).

Where the plant has undergone a significant number of modifications over its lifetime or in the period since the last PSR, the cumulative effects of all modifications on the design should be examined (for example, review of the loading on electrical supplies or post-trip cooling demands on water supplies).

The PSR should verify that significant documentation relating to the original and/or reconstituted design basis has been obtained, securely stored and updated to reflect all the modifications made to the plant since its commissioning.

A design re-evaluation should be undertaken if the design information is inadequate or there is significant uncertainty over the adequacy of an SSC important to safety to fulfil its safety function.

SAFETY FACTOR 1: PLANT DESIGN	
Inputs	**Outputs**
Standards and requirements: • Current national and international requirements and codes and standards on design and site evaluation; and • Current national and international good practices in design and site evaluation. Plant specific documents: • Relevant chapters of the final safety analysis report; • The site evaluation (from the final safety analysis report or similar safety document); • The list of SSCs important to safety and their safety classification (from the final safety analysis report or similar safety document); • The documented design basis (original or reconstituted and updated) including the list of postulated initiating events; • The detailed description of the plant design, supported by drawings of the layout, systems and equipment (from the final safety analysis report or similar safety document); • Technical specifications (as set out in the final safety analysis report); • Results of tests in the commissioning phase; and • Review compliance with plant design specifications. Operating experience: • Operating experience from similar plants; and • Actual physical condition of the plant.	The review of plant design may lead to findings in some of the following areas: • Compliance with current safety and design standards; • Defence in depth in the prevention and mitigation of events (faults and hazards) that could jeopardise safety; • Dependability requirements for SSCs important to safety; • Records of the design basis, modifications to the plant and test results; • The final safety analysis report; • Recommended plant modifications; and • New operational limits and conditions. On the basis of the results of the review, re-assessment of safety margins against current standards and requirements may be necessary. Results from the review of this safety factor may provide inputs for other safety factors (see Annexure B), for example in the following areas: • New safety margins; and • Plant design modifications.

The review of this safety factor may require input from other safety factors (see Annexure B), for example in the following areas: • New results of reviews of tests, inspections and maintenance and ageing margins; • Negative findings from equipment qualification; • Results from the evaluation of hazards; • Results of root cause analyses; and • New postulated initiating events and new technical solutions.	

Safety Factor 2: Actual Condition of Structures, Systems and Components

The actual condition of SSCs important to safety within the nuclear power plant is an important factor in any review of the safety of the plant design. Hence, it is important to document thoroughly the condition of each SSC important to safety. Additionally, knowledge of any existing or anticipated obsolescence of plant systems and equipment should be considered part of this safety factor.

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, at least until the next PSR. In addition, the review should verify that the condition of SSCs important to safety is properly documented, as well as reviewing the ongoing maintenance, surveillance and in-service inspection programmes, as applicable.

Scope and tasks

The review of the actual condition of the SSCs important to the safety of the nuclear power plant should include examination of the following aspects for each SSC:

- Existing or anticipated ageing processes;
- Operational limits and conditions;
- Current state of the SSC with regard to its obsolescence;
- Implications of changes to design requirements and standards on the actual condition of the SSC since the plant was designed or since the last PSR (for example, changes to standards on material properties);
- Plant programmes that support ongoing confidence in the condition of the SSC;
- Significant findings from tests of the functional capability of the SSC;
- Results of inspections and/or walkdowns of the SSC;
- Maintenance and validity of records;
- Evaluation of the operating history of the SSC;
- Dependence on obsolescent equipment for which no direct substitute is available;
- Dependence on essential services and/or supplies external to the plant;
- The condition and operation of spent fuel storage facilities and their effect on the spent fuel storage strategy for the nuclear power plant; and

- Verification of the actual state of the SSC against the design basis.

Methodology

The actual condition of the SSCs important to the safety of the nuclear power plant should be reviewed using knowledge of any existing or anticipated ageing processes or of obsolescence of plant systems and equipment, modification history and operating history. The implications of changes to design standards since the plant was designed or since the last PSR should be examined during the review of plant condition.

Inputs to the review of this safety factor should be made available from the ageing management programme of the authorisation holder. However, if this programme does not provide adequate information, the necessary inputs should be derived at an early stage of the PSR.

Where data are lacking, they should be generated or derived by performing special tests, plant walkdowns and inspections as necessary. The validity of existing records should be checked to ensure that they accurately represent the actual condition of the SSCs important to safety, including any significant findings from ongoing maintenance, tests and inspections.

It may not always be possible to determine the actual condition of SSCs important to safety in some areas of the plant owing to, for example, plant layout or operating conditions that may preclude inspection. Such instances should be highlighted and the safety significance of the resultant uncertainty in the true condition of the SSCs should be determined. These uncertainties may be reduced by considering evidence from similar components from other plants or facilities that are subject to similar conditions and/or knowledge of the relevant ageing processes and operating conditions.

For practical purposes, the review may group SSCs important to safety according to functional systems or type.

After determining the actual condition of the SSCs important to safety, each SSC should be assessed against the current or updated design basis to confirm that design basis assumptions have not been significantly challenged and will remain so until the next PSR.

Where consistency with the design basis has been significantly challenged, the PSR should make proposals for corrective action (for example, additional inspections or tests, further safety analysis or the replacement of components). These proposals should then be considered further in the global assessment.

SAFETY FACTOR 2: ACTUAL CONDITION OF STRUCTURES, SYSTEMS AND COMPONENTS	
Inputs	**Outputs**
Standards and requirements: • Current national and international requirements, codes and standards on design; • Appropriate standards on assessment; and • Operating experience from plants containing similar SSCs. Plant specific documents: • The list of SSCs important to safety and their safety classification; • Information about the integrity and functional capability of SSCs important to safety, including material case histories; • Descriptions of the actual condition of SSCs important to safety; • The assessment methods applied by the operator; • Technical specification of the SSCs important to safety; • Equipment qualification results; • Description of the support facilities available to the plant both on and off the site, including maintenance and repair shops; • Reports of walkdowns; • Maintenance records; • Inspection results;	Examples of findings from the review of the actual condition of the plant's structures, systems and components are the following: • Confirmation that the design basis assumptions have not been significantly challenged, with account taken of the actual condition of the plant, and will remain unchallenged until the next PSR; • The actual condition of the SSCs important to safety of the nuclear power plant is such that the design basis assumptions are not significantly challenged and will not be challenged before the next PSR; • Additional surveillance measures are necessary to ensure the timely detection of ageing effects; • Maintenance and testing need to be improved; • Processes do not maintain adequate records of the actual state of the plant, ageing processes and obsolescence of components; and • Validity of existing records is sufficient or has to be improved. Results from the review of this safety factor may provide inputs for other safety factors (see Annexure B).

• Findings of tests that demonstrate the functional capability of SSCs important to safety; • Operational data history and trends; • Outstanding maintenance and modifications; • Maintenance data, including data on repeated maintenance and corrective maintenance and reports of obsolescence; and • Records of modifications. The review of this safety factor may require input from other safety factors (see Annexure B), for example in the following areas: • Negative findings from equipment qualification; • Predictions of ageing and effectiveness of the ageing management programme; • New postulated initiating events; • New internal and external hazards; • Operating history; and • Configuration management.	

Safety Factor 3: Equipment Qualification

Plant equipment important to safety (that is, SSCs) should be properly qualified to ensure its capability to perform its safety functions under all relevant operational states and accident conditions, including those arising from internal and external events and accidents (such as loss of coolant accidents, high energy line breaks and seismic events or other vibration conditions). The qualification should adopt a graded approach consistent with the safety classification of the SSC and should be an ongoing activity.

Objective

The objective of the review of equipment qualification is to determine whether plant equipment important to safety has been properly qualified (including for environmental conditions) and whether this qualification is being maintained through an adequate programme of maintenance, inspection and testing that provides confidence in the delivery of safety functions until at least the next PSR.

Scope and tasks

The review of equipment qualification should include an assessment of the effectiveness of the plant's equipment qualification programme. This programme should ensure that plant equipment (including cables) is capable of fulfilling its safety functions for the period until at least the next PSR. The review should also cover the requirements for performing safety functions while subject to the environmental conditions that could exist during both normal and predicted accident conditions. These should include seismic conditions, vibration, temperature, pressure, jet impingement, electromagnetic interference, irradiation, corrosive atmosphere and humidity, fire (for example, a hydrogen fire) and combinations thereof and other anticipated events. The review should also consider the effects of ageing degradation of equipment during service and of possible changes in environmental conditions during normal operation and predicted accident conditions since the programme was devised.

Qualification of plant equipment important to safety should be formalised using a process that includes generating, documenting and retaining evidence that equipment can perform its safety functions during its installed service life. This should be an ongoing process, from its design through to the end of its service life. The process should take into account plant and

equipment ageing and modifications, equipment repairs and refurbishment, equipment failures and replacements, any abnormal operating conditions and changes to the safety analysis. Although many parties (such as designers, equipment manufacturers and consultants) will be involved in the equipment qualification process, the authorisation holder has the ultimate responsibility for the development and implementation of an adequate plant specific equipment qualification programme.

The review of equipment qualification should consider:

- Whether installed equipment meets the qualification requirements;
- The adequacy of the records of equipment qualification;
- Procedures for updating and maintaining qualification throughout the service life of the equipment;
- Procedures for ensuring that modifications and additions to SSCs important to safety do not compromise their qualification;
- Surveillance programmes and feedback procedures used to ensure that ageing degradation of qualified equipment remains insignificant;
- Monitoring of actual environmental conditions and identification of 'hot spots' of high activity or temperature; and
- Protection of qualified equipment from adverse environmental conditions.

Methodology

Plant equipment should be classified, designed, manufactured and qualified according to its importance to safety on the basis of relevant safety requirements and standards. At a minimum, the PSR should verify that the standards and requirements in use for equipment qualification at the plant remain valid. The review should also include assessment of the following:

- Changes in the equipment classification resulting from design modifications;
- Qualification for all designed environmental conditions;
- The availability of equipment that is required to fulfil safety functions; and
- Quality management provisions that ensure that an effective qualification programme is in place.

The review of equipment qualification should determine:

- Whether adequate assurance of the required equipment performance was initially provided;
- Whether current equipment qualification specifications and procedures are still valid (for example, initial assumptions regarding the service life of equipment and the environmental conditions); and
- Whether equipment performance has been preserved by ongoing application of measures such as scheduled maintenance, condition monitoring, testing and calibration and whether such programmes have been properly documented.

The review should evaluate the results of plant tests, inspections and walkdowns and other investigations carried out to assess the current condition of installed qualified equipment. This part of the review should seek to identify any differences from the qualified configuration (for example, abnormal conditions such as missing or loose bolts and covers, exposed wiring or damaged flexible conduits). The walkdowns and inspections should be carried out to verify that the installed equipment matches the required qualification described in the safety documentation and should provide an input to the review of the adequacy of the plant's procedures for maintaining equipment qualification.

SAFETY FACTOR 3: EQUIPMENT QUALIFICATION	
Inputs	**Outputs**
Standards and requirements: • Current national and international requirements and standards on design and site evaluation; and • Current national and international good practices in design and site evaluation. Plant specific documents: • The site evaluation (from the final safety analysis report or similar safety document); • The list of SSCs important to safety and their safety classification; • The documented design basis (original and updated) including the list of postulated initiating events and specific environmental parameters; • The list of equipment covered by the equipment qualification programme and the procedure for control of this list; • Equipment qualification report and other supporting documents (for example, equipment qualification specifications and qualification plan); and • Records of all qualification measures taken during the installed service life of the equipment. Operating experience: • Operating experience from similar plants. The review of this safety factor may require input from other safety factors (see Annexure B).	The review of equipment qualification may lead to findings in some of the following areas: • The equipment qualification programme, its procedures (including design extension conditions) and records; • The final safety analysis report; • Environmental conditions; and • Maintenance and ageing management programmes. Findings in the review of equipment qualification may result in one of the following: • Equipment qualification is adequate or justification is necessary; • Additional qualification or protection is needed for particular components; • Proposal for replacement of particular SSCs; • Improvements to the maintenance programme; or • Improvements to the ageing management programme. Results from the review of this safety factor may provide inputs for other safety factors (see Annexure B)

Safety Factor 4: Ageing

All SSCs important to the safety of nuclear power plants are subject to some form of physical change caused by ageing, which could eventually impair their safety functions and service lives.

Objective

The objective of the review of ageing is to determine whether ageing aspects affecting SSCs important to safety are being effectively managed and whether an effective ageing management programme is in place so that all required safety functions will be delivered for the design lifetime of the plant and, if it is proposed, for long term operation.

Scope and tasks

The review of ageing should include review of the ageing management programme established at the nuclear power plant. The review should evaluate both programmatic and technical aspects. The following aspects of the ageing management programme should be evaluated:

- The timely detection and mitigation of ageing mechanisms and/or ageing effects;
- The comprehensiveness of the programme, i.e. does it address all SSCs important to safety?
- The effectiveness of operating and maintenance policies and/or procedures for managing the ageing of replaceable components;
- Evaluation and documentation of potential ageing degradation that may affect the safety functions of SSCs important to safety;
- Management of the effects of ageing on those parts of the nuclear power plant that will be required for safety when the nuclear reactor has ceased operation, for example the spent fuel storage facilities;
- Performance indicators; and
- Record-keeping.

The review should evaluate the following technical aspects:

- Ageing management methodology;

- The authorisation holder's understanding of dominant ageing mechanisms and phenomena, including knowledge of actual safety margins;
- Availability of data for assessing ageing degradation, including baseline data and operating and maintenance histories;
- Acceptance criteria and required safety margins for SSCs important to safety;
- Operating guidelines aimed at controlling and/or moderating the rate of ageing degradation;
- Methods for monitoring ageing and for mitigation of ageing effects;
- Awareness of the physical condition of SSCs important to safety and any features that could limit service life;
- Understanding and control of ageing of all materials (including consumables, such as lubricants) and SSCs that could impair their safety functions; and
- Obsolescence of technology used in the nuclear power plant.

Methodology

The ageing management programme should be reviewed to confirm that it provides for the timely detection and prediction of ageing degradation that might affect the safety functions and service lives of SSCs important to safety, and that it identifies appropriate measures for the maintenance of these functions. Programme descriptions, evaluation of programmes and technical bases for programmes, plans for the reliability and availability of SSCs important to safety, the detection and mitigation of ageing effects, and the actual physical condition of structures and components should be examined. The review should focus on the integrated performance of the systems important to safety and on the results of periodic inspection and testing programmes and trends in important safety parameters.

The review should examine whether effective control of ageing degradation is achieved by means of a systematic ageing management process. Such a process consists of the following ageing management tasks, which should be carried out on the basis of a proper understanding of the ageing of the SSCs important to safety:

- Operation within operating guidelines with the aim of minimising the rate of ageing degradation;
- Inspection and monitoring consistent with the applicable requirements with the aim of timely detection and characterisation of any ageing degradation;

- Assessment of observed ageing degradation in accordance with appropriate guidelines in order to assess the integrity and functional capability of the structure or component; and
- Maintenance (that is, repair or replacement of parts) to prevent or remedy unacceptable ageing degradation.

The review should assess whether:

- A systematic, effective and comprehensive ageing management programme is in place;
- Any non-safety-classified SSCs whose failure might inhibit or adversely affect a safety function are addressed to an adequate extent;
- All relevant ageing degradation mechanisms are identified, and the models used to predict the evolution and advancement of ageing degradation are properly supported in accordance with current accepted practices pertaining to ageing degradation;
- Adequate measures are taken to monitor and control ageing processes; and
- The ageing management programme will ensure continued safe operation for at least the period until the next PSR.

SAFETY FACTOR 4: AGEING	
Inputs	**Outputs**
Standards and requirements: • Current national and international ageing management standards; and • Relevant guidance on the management of plant ageing and record-keeping. Plant specific documents: • Manuals on ageing management used by the authorisation holder; • Documentation on the method and criteria for identifying SSCs important to safety covered by the ageing management programme; • The list of SSCs important to safety covered by the ageing management programme and records that provide information in support of the management of ageing; and • Data for assessing ageing degradation, including baseline data and operating and maintenance histories. The review of this safety factor may require input from other safety factors (see Annexure B), for example in the area of operating history.	The review of ageing may lead to findings in some of the following areas: • The rapidity of the ageing process; and • Plant design review. Examples of outputs are: • Proposals for replacement of particular SSCs important to safety; • Improvements to the maintenance programme; and • Improvements to the ageing management programme. Results from the review of this safety factor may provide inputs for other safety factors (see Annexure B).

Safety Factor 5: Deterministic Safety Analysis

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

Objective

The objective of the review of this safety factor is to determine to what extent the existing deterministic safety analysis is complete and remains valid when the following aspects have been taken into account:

- The actual plant design, including all modifications of SSCs since the last update of the safety analysis report or the last PSR;
- Current operating modes and fuel management;
- The actual condition of SSCs important to safety and their predicted state at the end of the period covered by the PSR;
- The use of modern, validated computer codes;
- Current deterministic methods;
- Current safety standards and knowledge (including research and development outcomes); and
- The existence and adequacy of safety margins.

Scope and tasks

The review of the deterministic safety analysis should include the following tasks:

- Review of the application of analytical methods, guidelines and computer codes used in the existing deterministic safety analysis and comparison with current standards and requirements;
- Review of the current state of the deterministic safety analysis (original analysis and updated analysis) for the completeness of the set of postulated initiating events forming the design basis, with consideration given to feedback of operating experience from plants of a similar design;
- Evaluation of whether the assumptions made in performing the deterministic safety analysis remain valid given the actual condition of the plant;

- Evaluation of whether the actual operational conditions of the plant meet the acceptance criteria for the design basis;
- Evaluation of whether the assumptions used in the deterministic safety analysis are in accordance with current regulations and standards;
- Review of the application of the concept of defence in depth;
- Evaluation of whether appropriate deterministic methods have been used for development and validation of emergency operating procedures and the accident management programme at the plant;
- Evaluation of whether calculated radiation doses and releases of radioactive material in normal and accident conditions meet regulatory requirements and expectations; and
- Analysis of the functional adequacy and reliability of systems and components, the impact on safety of internal and external events, equipment failures and human errors, the adequacy and effectiveness of engineering and administrative measures to prevent and mitigate accidents.

Methodology

The review of deterministic safety analysis should provide a systematic re-examination of how operating experience feedback, new knowledge (for example, of physical phenomena) and changes in analysis and modelling techniques affect safety at the nuclear power plant.

The existing deterministic safety analysis should be reviewed against the current national and international requirements, standards and good practices to verify that the design basis for SSCs important to safety is correct and that plant behaviour for postulated initiating events is properly addressed to a current applicable standard.

The review should seek to identify (or confirm) any major weaknesses as well as strengths of the plant design in relation to the application of defence in depth, and should evaluate the importance of systems and measures for preventing or controlling accidents.

The capabilities of the plant in its current state, and where relevant with account taken of planned safety improvements, should be demonstrated to be within regulatory requirements and expectations for both normal operation and accident conditions.

If it is necessary to repeat the analysis, consideration should be given to using current analytical methods, particularly with regard to computer codes for transient analyses. If the earlier approach is still used, its continuing validity should be verified explicitly in the review, including the assumptions used, the degree of conservatism applied and inherent uncertainties in the analysis.

The review should include an evaluation of the supporting analyses for design extension conditions. 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.

SAFETY FACTOR 5: DETERMINISTIC SAFETY ANALYSIS	
Inputs	**Outputs**
Standards and requirements: • Current national and international guidelines for deterministic safety analysis, including guidelines for application of the single failure criterion and for redundancy, diversity and separation of SSCs important to safety. Plant specific documents: • The final safety analysis report, if available; • Compilation of the existing deterministic safety analysis and the assumptions used; • Operational limits and conditions and permitted operational states of the plant; • Anticipated operational occurrences, including the list of all postulated initiating events that could affect the safety of the plant; • Analytical methods and computer codes used in deterministic safety analysis and comparable current methods (e.g. those for use for a modern nuclear power plant), including their validation; and • Calculated radiation doses and limits on releases of radioactive material for design basis accident conditions. The review of this safety factor may require input from other safety factors (see Annexure B).	Examples of outputs are: • New postulated initiating events; • Revised operational limits and conditions; • Correctness of the assumptions used in the analysis; • Assessment of the capability of the design to provide for defence in depth; and • Proposed improvements to the deterministic analysis methodologies and/or modelling. Results from the review of this safety factor may provide inputs for other safety factors (see Annexure B).

Safety Factor 6: Probabilistic Safety Assessment

A review of the PSA should be conducted to identify weaknesses in the design and operation of the plant and, as part of the global assessment, to evaluate and compare proposed safety improvements.

Objective

The objectives of the review of the PSA are to determine:

- The extent to which the existing PSA study remains valid as a representative model of the nuclear power plant;
- Whether the results of the PSA show that the risks are sufficiently low and well balanced for all postulated initiating events and operational states;
- Whether the scope (which should include all operational states and identified internal and external hazards), methodologies and extent (i.e. Level 1, 2 or 3) of the PSA are in accordance with current national and international standards and good practices; and
- Whether the existing scope and application of the PSA are sufficient.

Scope and tasks

The review of the PSA should include the following aspects:

- The existing PSA, including the assumptions used, the fault schedule, the representations of operator actions and common cause events, the modelled plant configuration and consistency with other aspects of the safety case;
- Whether accident management programmes for accident conditions (design basis accident conditions and design extension conditions) are consistent with PSA models and results;
- Whether the scope and applications of the PSA are sufficient;
- The status and validation of analytical methods and computer codes used in the PSA;
- Whether the results of the PSA show that risks are sufficiently low and well balanced for all postulated initiating events and operational states, and meet relevant probabilistic safety criteria; and
- Whether the existing scope and application of the PSA are sufficient for its use to assist the PSR global assessment, for example, to compare proposed improvement options.

Methodology

The PSA should be reviewed to confirm that the modelling reflects the current design and operating features, takes account of all relevant operating experience, includes all modes of operation and, where relevant, has a scope agreed with the NNR.

The PSA should be reviewed for completeness against an appropriate set of postulated initiating events and hazards.

The extent to which hazards are represented in the PSA should be reviewed to verify that omissions are based on site specific justifications and that these omissions do not weaken the overall risk assessment for the plant.

The analytical methods and computer codes used in the PSA should be reviewed to verify that the methods used and validation standards adopted continue to be appropriate.

If it is necessary to repeat parts of the PSA, consideration should be given to using current PSA methodology (analytical methods and computer codes). If the earlier approach is still used, its continuing validity should be verified explicitly in the review, including the assumptions used, the degree of conservatism applied and inherent uncertainties in the analysis.

The extent to which the potential for unidentified cross-links and the effects of common cause events are taken into account in the model should be reviewed, as these are often not adequately considered in plants of earlier design.

The 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 that current methods are applied.

The results of the PSA should be compared with relevant probabilistic safety criteria (for example, for system reliability, core damage and releases of radioactive material) defined for the plant or set by the NNR.

The history of updates to the PSA to reflect changes in plant status should be reviewed. Ideally a living PSA should be maintained; however, where this is not practicable, the PSA should be kept sufficiently up to date throughout the lifetime of the plant to make it useful for safety decision-making.

SAFETY FACTOR 6: PROBABILISTIC SAFETY ASSESSMENT	
Inputs	**Outputs**
Standards and requirements: • Current national and international guidelines and codes for PSA, in particular those addressing operator actions, common cause events, cross-link effects and redundancy and diversity of SSCs important to safety. Plant specific documents: • Existing PSA documentation and models, including those used in risk informed applications of the PSA; • Postulated initiating events (those used for the existing PSA and a comparable list for a modern nuclear power plant); • Reports of external peer reviews and/or independent reviews; • A compilation or selection of guidelines, assessment principles, standards, regulatory requirements, etc. that represent what is considered the 'current standard' in performance of the PSA and the best practices known, available and applicable (all these should be used to derive criteria for the review of PSA); and • The accident management programme for design extension conditions together with results of the PSA. The review of this safety factor may require input from other safety factors (see Annexure B).	Examples of outputs are: • Revised operational limits and conditions; • Correctness of the assumptions used in the analysis; • Assessment of the capability of the design to provide for defence in depth; • Proposed improvements to the deterministic analysis methodologies and/or modelling; • Assessment of the adequacy of the accident management programme; • Identification of operational activities which are significant to safety; and • Improvements to the PSA reliability database. Results from the review of this safety factor may provide inputs for other safety factors (see Annexure B).

Safety Factor 7: Hazard Analysis

To ensure the delivery of required safety functions and operator actions, SSC important to safety, including the control room and the emergency control centre, should be adequately protected against relevant internal and external hazards.

Objective

The objective of the review of hazard analysis is to determine the adequacy of protection of the nuclear power plant against internal and external hazards, with account taken of the plant design, site characteristics, the actual condition of the SSCs important to safety and their predicted state at the end of the period covered by the PSR, and current analytical methods, safety standards and knowledge.

Scope and tasks

For each internal or external hazard identified, the review should evaluate the adequacy of the protection, with account taken of the following:

- The credible magnitude and associated frequency of occurrence of the hazard;
- Current safety standards;
- Current understanding of environmental effects;
- The capability of the plant to withstand the hazard as claimed in the safety case, based on its current condition and with allowance given to predicted ageing degradation; and
- The appropriateness of procedures to cover operator actions claimed to prevent or mitigate the hazard.

If it has not been previously done, a list of relevant internal and external hazards that may affect plant safety should be established. Where a list of relevant internal and external hazards has already been established, this should be reviewed for completeness.

The following representative internal hazards that may affect plant safety should be reviewed (additional site specific internal hazards should be included under this safety factor if appropriate):

- Fire (including measures for prevention, detection and suppression of fire);
- Flooding;

- Pipe whip;
- Missiles and drops of heavy loads;
- Steam release;
- Hot gas release;
- Cold gas release;
- Deluge and spray;
- Explosion;
- Electromagnetic or radio frequency interference;
- Toxic and/or corrosive liquids and gases;
- Vibration;
- Subsidence;
- High humidity;
- Structural collapse;
- Loss of internal and external services (cooling water, electricity, etc.);
- High voltage transients; and
- Loss or low capacity of air conditioning (which may lead to high temperatures).

The following representative external hazards that may affect plant safety should be reviewed (additional site specific external hazards should be included under this safety factor if appropriate):

- Floods, including tsunamis;
- High winds, including tornadoes;
- Fire;
- Meteorological hazards (extreme temperatures, extreme weather conditions, high humidity, drought, snow, buildup of ice);
- Sun storm;
- Toxic and/or corrosive liquids and gases, other contamination in the air intake (for example, industrial contaminants, volcanic ash);
- Hydrogeological and hydrological hazards (extreme groundwater levels, seiches);
- Seismic hazards;
- Volcano hazards;
- Aircraft crashes and external missiles;
- Explosion;
- Biological fouling;

- Lightning strike;
- Electromagnetic or radio frequency interference;
- Vibration;
- Traffic; and
- Loss of internal and external services (cooling water, electricity, etc.).

Methodology

For each relevant hazard, the review should verify, by means of current analytical techniques and data, that the frequency of occurrence and/or the consequences of the hazard are sufficiently low so that either no specific protective measures are necessary, or the preventive and mitigatory measures in place are adequate.

The analytical methods, safety standards and information used for the hazard analysis should be up to date and valid. If this is not the case, the analysis should be repeated or revised as necessary. The analysis and/or methods should take account of the plant design, site characteristics, the condition of SSCs important to safety (both at present and predicted for the end of the period covered by the PSR) and relevant international practice. Among other things, changes in plant design, the prevailing climate, the potential for floods and earthquakes, and transport and/or industrial activities near the site should be considered.

In considering the risk of a particular hazard, consideration should be given to experience of hazards and operating practices at nuclear power plants and at other facilities.

Knowledge gained from actual events, in particular those that have occurred at nuclear power plants, should be identified. Any experience from managing such events (for example, external floods, seismic events and tornadoes) should be used to improve existing procedures at the plant.

The adequacy of the procedures used to prevent a hazard or to mitigate its consequences should be reviewed, including the extent to which these are tested and rehearsed. The adequacy of the preventive and mitigatory measures can be evaluated by deterministic safety analysis or PSA.

SAFETY FACTOR 7: HAZARD ANALYSIS	
Inputs	**Outputs**
Standards and requirements: • Current national and international design codes, safety assessment standards and safety guides; • National regulations; and • Control procedures, safety assessment standards and safety guides of the authorisation holder. Plant specific (and site specific) documents: • Results of previous hazards analyses; • Flood risk assessments; • Climate change assessments; • Seismic assessments and records; • Fire protection plans; • PSA assumptions (where used); • Emergency plans; • Local patterns or trends of aircraft movement and records of overflight incidents; • Recent planning applications (future changes in industrial or transport activity near the plant); • Records of wind speeds and direction; • Records of volcanic activity and hazards; • Records of ambient and sea and river temperature; • Records of river and sea levels; • Records of meteorological hazards; and • Records of hydrological hazards. Operating experience: • Operating experience from similar plants or sites; and	Findings from the review of the hazard analysis could include the following: • The design basis assumptions will not be significantly challenged by internal or external hazards until at least the next PSR; • Need for reassessment of safety margins; • Procedures for mitigating the consequences of hazards need to be improved; • Equipment qualification needs to be reassessed; • Modifications are necessary to detect hazards or to improve mitigation of the consequences of hazards, for example, flood barriers need to be raised; • Additional monitoring and improved record-keeping are necessary; • Updates of the final safety analysis report are necessary; and • Plant modification processes or maintenance procedures do not take adequate account of requirements for hazards qualification. Results from the review of this safety factor review may provide inputs to other safety factors (see Annexure B).

• Records of hazard incidents affecting the plant. The review of this safety factor may require input from other safety factors (see Annexure B).	

Safety Factor 8: Safety Performance

Safety performance is determined from assessment of operating experience, including safety related events, and records of the unavailability of safety systems, radiation doses and the generation of radioactive waste and discharges of radioactive effluents.

Objective

The objective of the review of safety performance is to determine whether the plant's safety performance indicators and records of operating experience, including the evaluation of root causes of plant events, indicate any need for safety improvements.

Scope and tasks

The review of safety performance should evaluate whether the plant has in place appropriate processes for the routine recording and evaluation of safety related operating experience, including:

- Safety related incidents, low level events and near misses;
- Safety related operational data;
- Maintenance, inspection and testing;
- Replacements of SSCs important to safety owing to failure or obsolescence;
- Modifications, either temporary or permanent, to SSCs important to safety;
- Unavailability of safety systems;
- Radiation doses (to workers, including contractors);
- Off-site contamination and radiation levels;
- Discharges of radioactive effluents;
- Generation of radioactive waste; and
- Compliance with regulatory requirements.

The review of safety performance is closely linked to the review of the use of experience from other plants and research findings, but the review of safety performance should be restricted to operating experience at the plant under review.

Where safety performance indicators are used, the review should consider their adequacy and effectiveness, applying trend analysis and comparing performance levels with those for other plants.

The review should consider the effectiveness of the processes and methodology used to evaluate and assess operating experience and trends. The findings of the reviews of other safety factors should be taken into account when undertaking this task.

Records of radiation doses and radioactive effluents should be reviewed to determine whether these are within prescribed limits, as low as reasonably achievable and adequately managed. Although radiation risks will need to be considered in all safety factors, the review of this safety factor should specifically examine data on radiation doses and radioactive effluents and the effectiveness of the radiation protection measures in place. Here the review should take into account the types of activity being undertaken at the plant, which may not be directly comparable with those at other nuclear power plants.

Data on the generation of radioactive waste should be reviewed to determine whether operation of the plant is being optimised to minimise the quantities of waste being generated and accumulated, taking into account the national policy on radioactive discharges and international treaties, standards and criteria, etc.

Methodology

Where available, the review should utilise a set of safety performance indicators, which should cover in a systematic manner all aspects of operation important to safety. These indicators should provide information on both positive and negative aspects of safety performance.

The review should also examine any other records of operating experience from the review period that are relevant to safety but have not been considered on the basis of the plant's safety performance indicators.

The review of safety performance should evaluate the adequacy of the plant's safety performance methodologies and processes with regard to:

- The identification and classification of safety related events;
- Root cause analysis of incidents and feedback of results;

- Methods for the selection and recording of safety related operational data, including data on maintenance, testing and inspection;
- Trend analyses of safety related operational data;
- Trend analyses regarding component replacements owing to failures or obsolescence;
- Feedback of safety related operational data to the operating regime (for example, for training purposes);
- The qualification of workers;
- The quality of procedures and results;
- Records of radiation doses and radioactive effluents;
- Off-site and on-site contamination and radiation levels;
- Accumulation of radioactive waste;
- Compliance with regulatory requirements; and
- Implementation of corrective actions following events.

The analysis of trends over the operating lifetime of the plant or since the last PSR should be reviewed to identify potential future safety concerns (for example, precursors to accidents) 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.

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. In particular, the review should evaluate the continuing relevance of the current indicators and other safety performance methods in the context of current and future operations, and ensure that only relevant data and records are used.

SSR-2/2 [10] establishes the requirements for a radiation protection programme, including requirements on the assessment of occupational exposure and on the management of radioactive waste and effluents arising from the operation of a nuclear power plant. NS-G-2.2 [12], SSG-40 [6] and GSG-7 [8] provide relevant recommendations and further guidance. These IAEA safety standards should be considered when reviewing records relating to radiation doses, the generation of radioactive waste and the discharge of radioactive effluents.

The PSR should include a review of the effectiveness of the authorisation holder's process for the routine evaluation of operating experience. However, where a common process is applied by the authorisation holder at several plants, and this process has been reviewed by a recent

PSR at another plant, this element of the review could be confined to reviewing how the process is applied at the plant under review. SSG-50 [7] provides detailed recommendations on reviewing the effectiveness of the process for the feedback of operating experience.

The use of performance indicators also enables comparisons to be made with other nuclear power plants and provides an opportunity for authorisation holders to benefit from each other's experience. The extent to which this is being undertaken should be examined.

In cases where there are significant findings relating to the effectiveness of the feedback process, the PSR should carry out a full review of relevant operating experience at the plant over the review period.

Where the review indicates a weak performance or trend, possible root causes (for example, deficiencies in procedures, training or safety culture) should be identified.

For the purpose of providing data for other safety factors and for consideration in the global assessment, the results of the routine evaluations should be summarised (using, for example, indicators or trends) to provide an overall assessment of the safety performance for each year of the plant's operation over the review period. Trends should be reported and, where necessary, further analysis should be undertaken to highlight any potential safety problems.

SAFETY FACTOR 8: SAFETY PERFORMANCE	
Inputs	**Outputs**

Standards and requirements:
• Current national and international standards, requirements and good practices.
 	
Operating experience:
• Best international practice in the use of safety performance indicators developed by the IAEA and WANO.
 	
Plant specific documents:
• Records of operating experience relevant to safety, including the following:
  ○ Frequency of unplanned trips while the reactor is critical;
  ○ Frequency of unplanned operator actions in the interests of safety and their success rate;
  ○ Selected actuations of and/or demands of safety systems;
  ○ Failures of safety systems;
  ○ Unavailability of safety systems;
  ○ Trends in causes of failures (for example, operator errors and hardware faults);
  ○ The backlog of outstanding maintenance and configuration management;
  ○ The extent of repeat maintenance;
  ○ The extent of corrective (breakdown) maintenance;
  ○ The integrity of physical barriers for the containment of radioactive material;
  ○ Radiation doses to persons on the site (including collective doses);
	The review of safety performance may lead to findings in some of the following areas:
	• Training relating to safety performance;
	• Plant processes and procedures, for example, operating procedures and maintenance procedures;
	• Safety culture;
	• The final safety analysis report;
	• Strengths and weaknesses demonstrated by performance indicators; and
	• Input data for the PSA.
	
	Results from the review of this safety factor may provide inputs to other safety factors (see Annexure B).

○ Data from off-site radiation monitoring; ○ The annual rate of generation of radioactive waste and the quantity of waste stored on the site; ○ Quantities of radioactive effluents produced; ○ Reports on the routine analysis of safety performance indicators; and ○ Procedures, documentation and outputs from the plant's routine processes for the review of operating experience. The review of this safety factor may require input from other safety factors (see Annexure B).	

Safety Factor 9: Use of Experience from Other Plants and Research Findings

Experience from other nuclear power plants, and sometimes from non-nuclear facilities, together with research findings, can reveal previously unknown safety weaknesses or can help in solving existing problems. SSR-2/2 [10] requires the authorisation holder to obtain and evaluate information on operating experience at other plants and to derive lessons for its own operations. This should include information from other plants for which the authorisation holder is responsible and wider experience, including relevant information from non-nuclear facilities.

Objective

The objective of the review of this safety factor is to determine whether there is adequate feedback of relevant experience from other nuclear power plants and from the findings of research and whether this is used to introduce reasonable and practicable safety improvements at the plant or to the authorisation holder.

Scope and tasks

The review should identify operating experience reports and other information that may be important to nuclear safety at other plants owned by the authorisation holder, together with relevant experience and national and international research findings from nuclear and non-nuclear facilities. It should be verified that this information has been properly considered within the plant's routine evaluation processes and that appropriate action has been taken.

The review of this safety factor is closely related to the review of safety performance. However, unlike the review of safety performance, the review of the use of experience from other plants and research findings should seek to identify good practices and lessons learned elsewhere and take advantage of improved knowledge derived from research.

Methodology

The review of the use of experience from other plants and research findings should:

- Verify that arrangements are in place for the feedback of experience relevant to safety from other nuclear power plants and from relevant non-nuclear facilities;

- Review the effectiveness of such programmes for the timely feedback of operating experience and for their output; and
- Review the processes for assessing and, if necessary, implementing research findings and findings from operating experience relevant to safety.

Arrangements have been established for the dissemination of operating experience at nuclear power plants by the IAEA, the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development (OECD/NEA), WANO, the Institute of Nuclear Power Operations (INPO) and various plant owners' groups. The authorisation holder should have in place a process for receiving, analysing and acting upon such operating experience. The PSR should provide a summary of the findings from this process and should evaluate the effectiveness of the process. Where the review of effectiveness indicates significant shortcomings in the process, appropriate measures should be taken, including a repeat review of relevant events and information.

Arrangements for the dissemination of research findings may not be as well established as those from operating experience. The PSR should therefore pay particular attention to the adequacy of these arrangements and the timely implementation of research findings.

For an authorisation holder that has responsibility for more than one nuclear power plant, it may be advantageous to carry out a generic assessment applicable to several plants rather than to perform specific reviews for each plant. In such circumstances, a full review of the use of experience from other plants and research findings should be undertaken for a reference plant as part of a series of linked PSRs. Subsequent reviews for the other plants may then be limited to consideration of plant specific matters, with reference made to the full review.

SAFETY FACTOR 9: USE OF EXPERIENCE FROM OTHER PLANTS AND RESEARCH FINDINGS	
Inputs	**Outputs**
Standards and requirements: • Current national and international standards and safety requirements; and • Relevant guidelines from the OECD/NEA, WANO and INPO. Operating experience: • International databases collecting operating experience, such as the IAEA's International Reporting System for Operating Experience (IRS) database and databases of WANO, INPO and owners' groups; • Highlight reports and topical studies of the IRS and 'Significant Event Reports' and 'Significant Operating Experience Reports' issued by WANO; and • Operating experience from similar plants. Plant specific documents: The review of the use of experience from other plants and research findings should include, in particular, the following plant specific inputs: • Reports from the authorisation holder's routine assessment of operating experience at other plants; • Procedures and documentation governing the authorisation holder's process for the review of operating experience at other plants; • Assessments from the authorisation holder's review of emerging research findings; • Procedures and documentation governing the authorisation holder's routine process	IAEA Specific Safety Guide No. SSG-50 [7] provides examples of typical outcomes for this safety factor. Additional outcomes could include: • Proposals for improving arrangements for receipt of operating experience feedback from other plants; • Proposals for improved dissemination of operating experience feedback within the authorisation holder; and • Arrangements for the receipt of findings from relevant research programmes (including international programmes). Results from the review of this safety factor may provide inputs for other safety factors (see Annexure B). This safety factor should be reviewed early in the PSR programme.

for the assessment of research findings; and • Independent internal or external audits and self-assessments regarding operating experience and research findings. The review of this safety factor may require input from other safety factors (see Annexure B).	

Safety Factor 10: Organisation, the Management System and Safety Culture

The authorisation holder is required to have in place a management system that ensures that policies and objectives are implemented in a safe, efficient and effective manner. Similarly, the authorisation holder should have a strong safety culture so that all individuals carry out duties important to safety correctly, with alertness, due thought, full knowledge, sound judgement and a proper sense of accountability.

Objective

The objective of the review of this safety factor is to determine whether the organisation, management system and safety culture are adequate and effective for ensuring the safe operation of the nuclear power plant.

Scope and tasks

The review of the organisation and management system should include a review of the following elements or programmes against NNR requirements and international standards:

- Policy statements of the authorisation holder;
- The documentation of the management system;
- The adequacy of arrangements for managing and retaining responsibility for activities or processes important to safety that have been outsourced (for example, maintenance and engineering services and safety analysis);
- The roles and responsibilities of individuals managing, performing and assessing work; and
- The processes and supporting information that explain how work is to be specified, prepared, reviewed, performed, recorded, assessed and improved.

In addition, the review of the organisation and management system should verify the following:

- There are adequate processes in place for managing organisational change.
- There is a human resource management process in place that ensures the availability of adequate, qualified human resources, including succession planning.
- There is adequate control of documents, products and records and this information is readily retrievable.

- There is adequate control of purchasing of equipment and services where this affects plant safety:
  - There are adequate processes in place to check the quality of suppliers' management systems that are intended to ensure that equipment and services supplied to the nuclear power plant are fit for purpose and provided in an effective and efficient manner.
- There are adequate communication policies in place.
- There are adequate facilities for training and training programmes are well structured.
- There are formal arrangements in place for employing suitably qualified internal and external technical, maintenance or other specialised staff.
- There are adequate processes in place for feedback of operating experience to the staff, including experience relating to organisational and management failures.
- There are suitable arrangements in place for maintaining the configuration of the nuclear power plant and operations are carried out in accordance with the safety analysis of the plant.
- There are programmes in place for ensuring continuous improvement, including self-assessment and independent assessment.

The review of safety culture is an assessment of commitment to safety and should include the following:

- A review of the safety policy to verify that it states that safety takes precedence over production and to confirm that this policy is effectively implemented;
- A review of procedures to ensure that nuclear and radiation safety are properly controlled and that appropriate measures are applied consistently and conscientiously by all staff;
- An assessment of the extent to which a questioning attitude exists and conservative decision-making is undertaken in the organisation;
- Verification that there is a strong drive to ensure that all events that may be instructive are reported and investigated to discover root causes and that timely feedback is provided to appropriate staff on findings and remedial actions;
- Verification that unsafe acts and conditions are identified and challenged in a constructive manner wherever and whenever they are encountered by plant employees and external staff (contractors);

- Verification that the authorisation holder has a learning culture and that it strives continuously for improvements and new ideas, and benchmarks against and searches out best practices and new technologies;
- Verification that there is an established and effective process for communication of safety issues;
- Verification that there is a process in place for prioritisation of safety issues, with realistic objectives and timescales, that ensures that these issues receive proper resources;
- Verification that there is a method in place for achieving and maintaining clarity of the organisational structure and managing changes in accountability for matters affecting safety; and
- Verification that there is adequate training in safety culture, particularly for managers.

Methodology

Regular and systematic reviews of the management system are necessary to ensure that the safety policies, goals and objectives of the organisation are being met as required. These reviews should include evaluation of how the tasks indicated in the review of safety culture are being undertaken and completed. This can be achieved by the review of independent audits carried out on behalf of senior management, task observations, self-assessments and supporting corrective action plans.

The review should examine whether regular management system reviews have been conducted at sufficient intervals and whether the following have been covered:

- Outputs from all forms of assessment (audits, self-assessments and task observations);
- Results delivered and objectives achieved by the authorisation holder and its processes;
- Non-conformances and corrective and preventive actions;
- Lessons learned from other organisations; and
- Opportunities for improvement.

The review should also examine whether weaknesses and obstacles have been identified, evaluated and remedied in a timely manner. It should also examine whether the need to make

changes to, or improvements in, policies, goals, strategies, plans, objectives and processes has been properly identified in the management system reviews.

An assessment of safety culture could include interviews of personnel at all levels of the authorisation holder and personnel providing support services. In such cases, the review team should include behavioural scientists to carry out the safety culture assessment.

SAFETY FACTOR 10: ORGANISATION, THE MANAGEMENT SYSTEM AND SAFETY CULTURE	
Inputs	**Outputs**
Standards and requirements: • Current national and international standards and regulations; and • Current national and international good practices. Plant specific documents: • The authorisation holder's safety policy and related documentation; • Procedures and documentation of the management system (for example, on quality management, configuration management and ageing management); • Outputs from application of management system procedures, including quality plans; • Records (for example, on training, commissioning, maintenance, testing); • Documentation describing the organisational structure and safety related roles and responsibilities of individuals and groups; • Corrective action programme and processes for reporting; and • Surveys of safety culture.	The review of organisation, the management system and safety culture may lead to findings in some of the following areas: • Clarity of policy statements; • Adequacy of the documentation of the management system; • Structure of the authorisation holder; • Work processes (how work is specified, prepared, reviewed, performed, recorded, assessed and improved); • Control of documents, products and records; • The purchasing process; • Communication; • Organisational change management; • Commitment to safety; • Compliance with procedures; • The existence of a questioning attitude among personnel; • Whether the authorisation holder has a 'learning culture'; • Prioritisation of safety issues; • Clarity of organisational roles and responsibilities; • Training on safety culture; and • Regular safety culture assessments.

Operating experience: • Operating experience with respect to organisation and administration at plants; • Internal audit and surveillance reports; • External audits (for example, reports from IAEA Operational Safety Review Team missions); • Self-assessments; • Safety performance assessments; and • Safety culture assessments. The review of this safety factor may require input from other safety factors (see Annexure B).	Results from the review of this safety factor may provide inputs for other safety factors (see Annexure B).

Safety Factor 11: Procedures

Procedures important to the safety of the nuclear power plant should be comprehensive, validated, formally approved, appropriately distributed and subject to rigorous management control. In addition, the procedures should be unambiguous and relevant to the actual plant (with modifications taken into account); they should reflect current operating practices and due consideration should be given to human factor aspects (for example, whether they are user-friendly).

Objective

The objective of the review of procedures is to determine whether the authorisation holder's processes for managing, implementing and adhering to operating and working procedures and for maintaining compliance with operational limits and conditions and regulatory requirements are adequate and effective and ensure plant safety.

Scope and tasks

The review should examine the following types of procedures:

- Operating procedures for normal and abnormal conditions (including anticipated operational occurrences, design basis accident conditions and post-accident conditions);
- Procedures for the management of design extension conditions, including accidents with significant core degradation (for example, symptom-based emergency operating procedures);
- Maintenance, testing and inspection procedures;
- Procedures for issuing work permits;
- Procedures for controlling modifications to the plant design, procedures and hardware, including the updating of documentation;
- Procedures for controlling the operating configuration;
- Procedures for radiation protection, including procedures for on-site transport of radioactive material; and
- Procedures for management of radioactive effluents and waste.

Methodology

The review of procedures should:

- Verify that there is an effective process in place for formal approval and documentation of all safety related procedures.
- Verify that there is a formal system in place for development and modification of any procedure governing activities affecting safety, including adequate arrangements for tracking changes.
- Evaluate audits, self-assessments, safety performance and events to determine whether there is adequate understanding and acceptance of these procedures by managers and staff.
- Determine whether procedures are followed.
- Evaluate the adequacy of these procedures in comparison with good practices.
- Determine whether arrangements for regular review and maintenance of these procedures are in place and are adequate.
- Verify that procedures are structured and written with consideration given to human factors. For example, it should be checked whether the procedures are user-friendly and can be readily understood and implemented by all staff who need to use them.
- Evaluate processes to update procedures to allow for changes in the assumptions made and/or the limits and conditions arising from the safety analysis, plant design and operating experience.
- Verify that the analysis and justification of the accident management procedures are documented.
- Verify that an appropriate process is in place for the categorisation of procedures in accordance with their significance to safety.
- Examine whether there is adequate involvement in the development of procedures by the staff who will use them.
- Evaluate the distribution process for the control, copying and removal of obsolete versions of procedures, so that only the last approved edition is used.

The review of this safety factor should focus on those procedures that have the highest safety significance and need not necessarily include a full review of every procedure. The safety significance of procedures can be determined from deterministic safety analysis and/or PSA. For procedures assigned lower safety significance, a sampling approach could be followed to

review the overall adequacy of procedures (and the management processes used to develop and control them).

SAFETY FACTOR 11: PROCEDURES	
Inputs	**Outputs**
Standards and requirements: • Current national and international requirements for procedures; and • Current national and international good practices in procedures. Plant specific documents: • Plant operating procedures for normal operation, fault conditions and symptom-based emergency operating procedures for restoring critical safety functions; • Procedures supporting plant operating procedures (for example, for their development, validation, acceptance, modification, withdrawal); and • Audits and self-assessments that question adherence to plant procedures. Operating experience: • Operating experience involving procedural issues at plants; and • Safety significant events involving procedural issues. The review of this safety factor may require input from other safety factors (see Annexure B).	The review of procedures may lead to findings in some of the following areas: • The process for development, elaboration, validation, acceptance, modification and withdrawal of procedures; • Clarity of procedures; • Compliance with procedures; • Effectiveness and adequacy of procedures; and • Safety culture. Results from the review of this safety factor may provide inputs for other safety factors (see Annexure B).

Safety Factor 12: Human Factors

Human factors influence all aspects of the safety of a nuclear power plant. The review should examine the human factors at the plant and within the authorisation holder's organisation to determine whether these correspond to accepted good practices and to verify that they do not present an unacceptable contribution to risk. In particular, the review should determine whether operator actions claimed to be in support of safety are feasible and properly supported.

Objective

The objective of the review of this safety factor is to evaluate the various human factors that may affect the safe operation of the nuclear power plant and to seek to identify improvements that are reasonable and practicable.

Scope and tasks

The review of human factors should consider the procedures and processes in place at the nuclear power plant to ensure the following:

- Adequate staffing levels exist for operating the plant, with due recognition given to absences, shift working and restrictions on overtime;
- Qualified staff are available on duty at all times;
- Adequate programmes are in place for initial training, refresher training and upgrading training, including the use of simulators;
- Operator actions needed for safe operation have been assessed to confirm that assumptions and claims made in safety analyses (for example, PSA, deterministic safety analysis and hazard analysis) are valid;
- Human factors in maintenance are assessed to promote error-free execution of work;
- Adequate competence requirements exist for operating, maintenance, technical and managerial staff;
- Staff selection methods (for example, testing for aptitudes, knowledge and skills) are systematic and validated;
- Appropriate fitness for duty guidelines exist relating to hours, types and patterns of work, good health and substance abuse;

- Policies exist for maintaining the know-how of staff and for ensuring adequate succession management in accordance with good practices; and
- Adequate facilities and programmes are available for staff training.

The following aspects of the human–machine interface should also be reviewed:

- Design of the control room and other workstations relevant to safety;
- Human information requirements and workloads; and
- Clarity and achievability of procedures.

Methodology

The review of human factors should include the above tasks and should take account of recognised national and international good practices.

The review should be carried out with the assistance of properly qualified specialists. Because of the difficulties associated with carrying out an objective review of what is essentially the performance of its own staff, the authorisation holder may decide that specific elements of the review should be carried out by external consultants.

The review of the human–machine interface should examine the actual condition of the plant using, for example, plant walkdowns by specialists.

If deficiencies in the procedures and processes or in the design of the human–machine interface represent a potentially significant adverse contribution to risk, the PSR should make proposals for corrective actions to be considered in the global assessment. These may include improvements in procedures, enhanced training or redesign of human–machine interfaces.

SAFETY FACTOR 12: HUMAN FACTORS	
Inputs	**Outputs**
Standards and requirements: • NNR and international requirements; and • Current national and international good practices for ensuring that human factors do not affect the safe operation of the nuclear power plant. Plant specific documents: • Policy to maintain the know-how of the plant staff; • Training records, also for training in safety culture, particularly for staff in management positions; • Staffing records; • Fitness for duty requirements; • Programmes for the feedback of operating experience for failures and/or errors in human performance that have contributed to safety significant events and their causes, and consequent corrective actions and/or safety improvements; and • Audits and self-assessments of hours of work and time records. Operating experience: • Operating experience involving human factors at plants; and • Safety significant events involving human factors. The review of this safety factor may require input from other safety factors (see Annexure B).	The review of human factors may lead to findings in some of the following areas: • Staffing levels; • Training programmes; • Operating, maintenance and engineering practices; • Competency management; • Staff selection and recruitment and succession management; • Knowledge management; • Use of external technical resources; • The human–machine interface; and • Communications. Results from the review of this safety factor may provide inputs for other safety factors (see Annexure B).

Safety Factor 13: Emergency Planning

The design and operation of a nuclear power plant are required to prevent or otherwise minimise releases 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 authorisation holder but also for local and national authorities.

Objective

The objective of the review of emergency planning is to determine:

- Whether the authorisation holder has in place adequate plans, staff, facilities and equipment for dealing with emergencies; and
- Whether the authorisation holder's arrangements have been adequately coordinated with the arrangements of local and national authorities and are regularly exercised.

Scope and tasks

The PSR should include an overall review to check that emergency planning at the plant continues to be satisfactory and to check that emergency plans are maintained in accordance with current safety analyses, accident mitigation studies and good practices.

The PSR should verify that the authorisation holder has given adequate consideration to significant changes at the site of the nuclear power plant and in its use, organisational changes at the plant, changes in the maintenance and storage of emergency equipment and developments around the site that could influence emergency planning.

The review of emergency planning should:

- Evaluate the adequacy of on-site equipment and facilities for emergencies;
- Evaluate the adequacy of on-site technical and operational support centres;
- Evaluate the efficiency of communications in the event of an emergency, in particular the interaction with organisations outside the plant;
- Evaluate the content and efficiency of emergency training and exercises and check records of experience from such exercises;

- Evaluate arrangements for the regular review and updating of emergency plans and procedures;
- Examine changes in the maintenance and storage of emergency equipment; and
- Evaluate the effects of any recent residential and industrial developments around the site.

Methodology

Records of emergency exercises should be reviewed to evaluate the effectiveness and competence of the staff of the authorisation holder and of off-site (emergency) organisations, the required functional capability of equipment (including communications equipment) and the adequacy of emergency planning.

The authorisation holder's arrangements for interaction with relevant off-site organisations such as the police, fire departments, hospitals, ambulance services, regulatory bodies, local authorities, government, public welfare authorities and the news media should be evaluated.

The review of the adequacy of on-site equipment and facilities for emergencies and off-site emergency facilities or locations should include walkdowns of relevant areas on and off the site.

The content and effectiveness of emergency training and exercises should be evaluated by reviewing the records of these exercises with respect to, for example, their frequency and results, and the actions taken in case of deficiencies. These can be compared with current national and international guidelines and good practices.

Arrangements for regular reviews of emergency plans and procedures and their periodic updating can be evaluated as part of the review of the authorisation holder's management processes.

SAFETY FACTOR 13: EMERGENCY PLANNING	
Inputs	**Outputs**
Standards and requirements: • Current national and international standards on emergency planning. Plant specific documents: • The emergency planning manual of the authorisation holder; • Strategy, procedures and organisation for emergencies; • Studies of the mitigation of consequences of accidents; and • Procedures for the management of design extension conditions and accident management guidelines. Operating experience: • Records of emergency exercises held and lessons learned; and • Lessons learned from international exercises. The review of this safety factor may require input from other safety factors (see Annexure B), particularly input from the review of PSA if appropriate analyses are available (Level 3 PSA or at least Level 2 PSA).	The review of emergency planning may lead to findings in some of the following areas: • Status of the emergency preparedness of the plant; • Confirmation that an effective emergency planning process is in place; • Technical and/or administrative improvements for communication with external bodies are necessary; • Emergency training with other organisations needs to be improved; and • Emergency plans need to be updated in accordance with the results of current safety analyses, accident mitigation studies and good practices. Results from the review of this safety factor may provide inputs for other safety factors (see Annexure B).

Safety Factor 14: Radiological Impact on the Environment

The authorisation holder should have in place an established and effective monitoring programme that provides data on the radiological impact of the nuclear power plant on its surroundings.

Objective

The objective of the review of this safety factor is to determine whether the authorisation holder has an adequate and effective programme for monitoring the radiological impact of the plant on the environment, which ensures that emissions are properly controlled and are as low as reasonably achievable.

Scope and tasks

Radiological monitoring data should be compared with the values measured before the nuclear power plant was put into operation and/or historical values examined in the last PSR. In the event of significant deviations, an explanation should be provided by the authorisation holder, with account taken of relevant factors external to the nuclear power plant.

Where environmental data have not been provided since the start of operation of the plant or since the last PSR, these data should be submitted to the NNR for information.

Methodology

The review should establish whether the monitoring programme is appropriate and sufficiently comprehensive. In particular, the review should verify that the radiological impact of the plant on the environment is not significant compared with that due to other sources of radiation.

In some cases monitoring programmes are also carried out by public organisations. This can facilitate the independent validation of data provided by the authorisation holder. Examples of data collected by other organisations include data on the concentrations of radionuclides in air, water (including river water, seawater and groundwater), soil, agricultural and marine products and wild flora and fauna.

As part of the review it should be verified that:

- Concentrations of radionuclides in air, water (including river water, seawater and groundwater), soil, agricultural and marine products and animals are being monitored by the authorisation holder or by an independent public organisation and are trended, and appropriate corrective actions are taken in the event that action levels are exceeded;
- Potential new sources of radiological impact have been recognised by the authorisation holder;
- Sampling and measurement methods are consistent with current standards;
- Records of discharges of effluents are being monitored and trended and appropriate actions are taken to remain within established limits and to keep such discharges as low as reasonably achievable;
- On-site monitoring is undertaken at locations and using methods that have a high probability of the prompt detection of a release of radioactive material to the environment;
- Off-site monitoring for contamination levels and radiation levels is adequate and corrective actions are taken to keep such levels as low as reasonably achievable;
- Actions have been taken to clean up contamination where reasonable and practicable;
- Alarm systems to respond to unplanned releases of radioactive material from on-site facilities are suitably designed and available and will remain available in the future;
- Appropriate data have been published on the environmental impact of the plant; and
- Changes in the use of areas around the site have been taken into account in the development of monitoring programmes.

The review should also look for potential new sources of radiological impact by examining relevant plant modifications and the actual conditions of SSCs important to safety.

SAFETY FACTOR 14: RADIOLOGICAL IMPACT ON THE ENVIRONMENT	
Inputs	**Outputs**
Standards and requirements: • Relevant NNR requirements; • IAEA Safety Requirements and Safety Guides, including SSR-2/1 [9], NS-G-1.13 [11] and NS-G-3.2 [13]; and • Relevant guidelines from the OECD/NEA, WANO and INPO. Plant specific documents: • Potential sources of radiological impact; • Release limits for effluents; • Off-site monitoring for contamination levels and radiation levels; • Availability of alarm systems to respond to unplanned releases of effluents from on-site facilities; • Recent and future changes in the use of areas around the site; • Records of effluent releases; • Records from off-site environmental monitoring; and • Published environmental data. The review of this safety factor may require input from other safety factors (see Annexure B), particularly from the reviews of plant design and of safety performance.	Results from the review of this safety factor may provide inputs to the reviews of all the other safety factors (see Annexure B).