IAEA Safety Standards

for protecting people and the environment

Periodic Safety Review for Nuclear Power Plants

Specific Safety Guide

No. SSG-25

IAEA
International Atomic Energy Agency

IAEA SAFETY STANDARDS AND RELATED PUBLICATIONS

IAEA SAFETY STANDARDS

Under the terms of Article III of its Statute, the IAEA is authorized to establish or adopt standards of safety for protection of health and minimization of danger to life and property, and to provide for the application of these standards.

The publications by means of which the IAEA establishes standards are issued in the **IAEA Safety Standards Series**. This series covers nuclear safety, radiation safety, transport safety and waste safety. The publication categories in the series are **Safety Fundamentals**, **Safety Requirements** and **Safety Guides**.

Information on the IAEA's safety standards programme is available at the IAEA Internet site

http://www-ns.iaea.org/standards/

The site provides the texts in English of published and draft safety standards. The texts of safety standards issued in Arabic, Chinese, French, Russian and Spanish, the IAEA Safety Glossary and a status report for safety standards under development are also available. For further information, please contact the IAEA at PO Box 100, 1400 Vienna, Austria.

All users of IAEA safety standards are invited to inform the IAEA of experience in their use (e.g. as a basis for national regulations, for safety reviews and for training courses) for the purpose of ensuring that they continue to meet users' needs. Information may be provided via the IAEA Internet site or by post, as above, or by email to Official.Mail@iaea.org.

RELATED PUBLICATIONS

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Reports on safety and protection in nuclear activities are issued as **Safety Reports**, which provide practical examples and detailed methods that can be used in support of the safety standards.

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Security related publications are issued in the **IAEA Nuclear Security Series**.

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PERIODIC SAFETY REVIEW FOR NUCLEAR POWER PLANTS

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The Agency's Statute was approved on 23 October 1956 by the Conference on the Statute of the IAEA held at United Nations Headquarters, New York; it entered into force on 29 July 1957. The Headquarters of the Agency are situated in Vienna. Its principal objective is "to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world''.

IAEA SAFETY STANDARDS SERIES No. SSG-25

PERIODIC SAFETY REVIEW FOR NUCLEAR POWER PLANTS

SPECIFIC SAFETY GUIDE

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FOREWORD

by Yukiya Amano
Director General

The IAEA's Statute authorizes the Agency to "establish or adopt… standards of safety for protection of health and minimization of danger to life and property" — standards that the IAEA must use in its own operations, and which States can apply by means of their regulatory provisions for nuclear and radiation safety. The IAEA does this in consultation with the competent organs of the United Nations and with the specialized agencies concerned. A comprehensive set of high quality standards under regular review is a key element of a stable and sustainable global safety regime, as is the IAEA's assistance in their application.

The IAEA commenced its safety standards programme in 1958. The emphasis placed on quality, fitness for purpose and continuous improvement has led to the widespread use of the IAEA standards throughout the world. The Safety Standards Series now includes unified Fundamental Safety Principles, which represent an international consensus on what must constitute a high level of protection and safety. With the strong support of the Commission on Safety Standards, the IAEA is working to promote the global acceptance and use of its standards.

Standards are only effective if they are properly applied in practice. The IAEA's safety services encompass design, siting and engineering safety, operational safety, radiation safety, safe transport of radioactive material and safe management of radioactive waste, as well as governmental organization, regulatory matters and safety culture in organizations. These safety services assist Member States in the application of the standards and enable valuable experience and insights to be shared.

Regulating safety is a national responsibility, and many States have decided to adopt the IAEA's standards for use in their national regulations. For parties to the various international safety conventions, IAEA standards provide a consistent, reliable means of ensuring the effective fulfilment of obligations under the conventions. The standards are also applied by regulatory bodies and operators around the world to enhance safety in nuclear power generation and in nuclear applications in medicine, industry, agriculture and research.

Safety is not an end in itself but a prerequisite for the purpose of the protection of people in all States and of the environment — now and in the future. The risks associated with ionizing radiation must be assessed and controlled without unduly limiting the contribution of nuclear energy to equitable and sustainable development. Governments, regulatory bodies and operators everywhere must ensure that nuclear material and radiation sources are used beneficially, safely and ethically. The IAEA safety standards are designed to facilitate this, and I encourage all Member States to make use of them.

NOTE BY THE SECRETARIAT

The IAEA safety standards reflect an international consensus on what constitutes a high level of safety for protecting people and the environment from harmful effects of ionizing radiation. The process of developing, reviewing and establishing the IAEA standards involves the IAEA Secretariat and all Member States, many of which are represented on the four IAEA safety standards committees and the IAEA Commission on Safety Standards.

The IAEA standards, as a key element of the global safety regime, are kept under regular review by the Secretariat, the safety standards committees and the Commission on Safety Standards. The Secretariat gathers information on experience in the application of the IAEA standards and information gained from the follow-up of events for the purpose of ensuring that the standards continue to meet users' needs. The present publication reflects feedback and experience accumulated until 2010 and it has been subject to the rigorous review process for standards.

Lessons that may be learned from studying the accident at the Fukushima Daiichi nuclear power plant in Japan following the disastrous earthquake and tsunami of 11 March 2011 will be reflected in this IAEA safety standard as revised and issued in the future.

THE IAEA SAFETY STANDARDS

BACKGROUND

Radioactivity is a natural phenomenon and natural sources of radiation are features of the environment. Radiation and radioactive substances have many beneficial applications, ranging from power generation to uses in medicine, industry and agriculture. The radiation risks to workers and the public and to the environment that may arise from these applications have to be assessed and, if necessary, controlled.

Activities such as the medical uses of radiation, the operation of nuclear installations, the production, transport and use of radioactive material, and the management of radioactive waste must therefore be subject to standards of safety.

Regulating safety is a national responsibility. However, radiation risks may transcend national borders, and international cooperation serves to promote and enhance safety globally by exchanging experience and by improving capabilities to control hazards, to prevent accidents, to respond to emergencies and to mitigate any harmful consequences.

States have an obligation of diligence and duty of care, and are expected to fulfil their national and international undertakings and obligations.

International safety standards provide support for States in meeting their obligations under general principles of international law, such as those relating to environmental protection. International safety standards also promote and assure confidence in safety and facilitate international commerce and trade.

A global nuclear safety regime is in place and is being continuously improved. IAEA safety standards, which support the implementation of binding international instruments and national safety infrastructures, are a cornerstone of this global regime. The IAEA safety standards constitute a useful tool for contracting parties to assess their performance under these international conventions.

THE IAEA SAFETY STANDARDS

The status of the IAEA safety standards derives from the IAEA's Statute, which authorizes the IAEA to establish or adopt, in consultation and, where appropriate, in collaboration with the competent organs of the United Nations and with the specialized agencies concerned, standards of safety for protection of health and minimization of danger to life and property, and to provide for their application.

With a view to ensuring the protection of people and the environment from harmful effects of ionizing radiation, the IAEA safety standards establish fundamental safety principles, requirements and measures to control the radiation exposure of people and the release of radioactive material to the environment, to restrict the likelihood of events that might lead to a loss of control over a nuclear reactor core, nuclear chain reaction, radioactive source or any other source of radiation, and to mitigate the consequences of such events if they were to occur. The standards apply to facilities and activities that give rise to radiation risks, including nuclear installations, the use of radiation and radioactive sources, the transport of radioactive material and the management of radioactive waste.

Safety measures and security measures[1] have in common the aim of protecting human life and health and the environment. Safety measures and security measures must be designed and implemented in an integrated manner so that security measures do not compromise safety and safety measures do not compromise security.

The IAEA safety standards reflect an international consensus on what constitutes a high level of safety for protecting people and the environment from harmful effects of ionizing radiation. They are issued in the IAEA Safety Standards Series, which has three categories (see Fig. 1).

Safety Fundamentals

Safety Fundamentals present the fundamental safety objective and principles of protection and safety, and provide the basis for the safety requirements.

Safety Requirements

An integrated and consistent set of Safety Requirements establishes the requirements that must be met to ensure the protection of people and the environment, both now and in the future. The requirements are governed by the objective and principles of the Safety Fundamentals. If the requirements are not met, measures must be taken to reach or restore the required level of safety. The format and style of the requirements facilitate their use for the establishment, in a harmonized manner, of a national regulatory framework. Requirements, including numbered 'overarching' requirements, are expressed as 'shall' statements. Many requirements are not addressed to a specific party, the implication being that the appropriate parties are responsible for fulfilling them.

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[1] See also publications issued in the IAEA Nuclear Security Series.

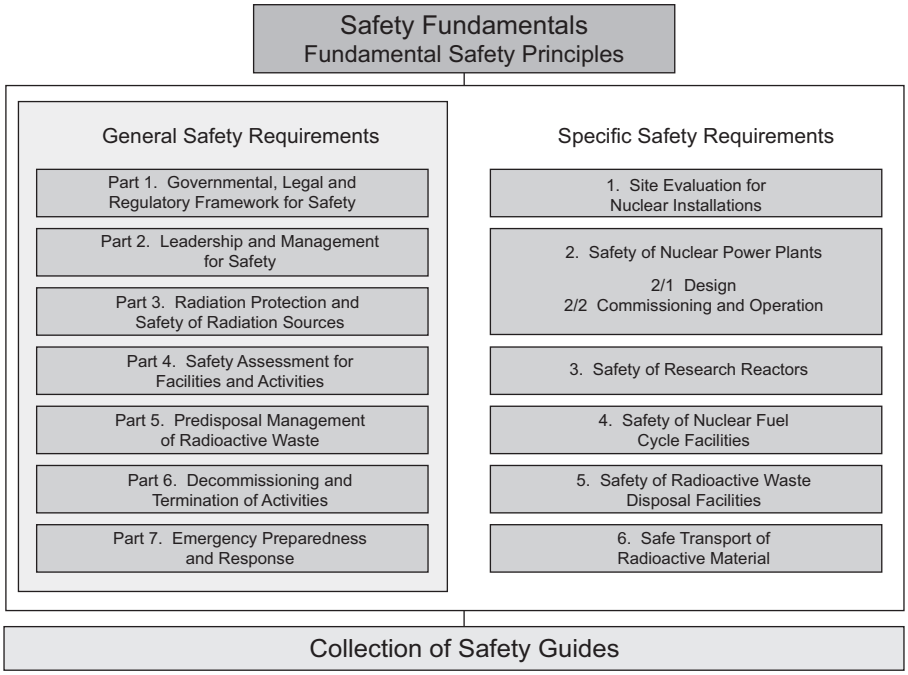

FIG. 1. The long term structure of the IAEA Safety Standards Series.

Safety Guides

Safety Guides provide recommendations and guidance on how to comply with the safety requirements, indicating an international consensus that it is necessary to take the measures recommended (or equivalent alternative measures). The Safety Guides present international good practices, and increasingly they reflect best practices, to help users striving to achieve high levels of safety. The recommendations provided in Safety Guides are expressed as 'should' statements.

APPLICATION OF THE IAEA SAFETY STANDARDS

The principal users of safety standards in IAEA Member States are regulatory bodies and other relevant national authorities. The IAEA safety standards are also used by co-sponsoring organizations and by many organizations that design, construct and operate nuclear facilities, as well as organizations involved in the use of radiation and radioactive sources.

The IAEA safety standards are applicable, as relevant, throughout the entire lifetime of all facilities and activities — existing and new — utilized for peaceful purposes and to protective actions to reduce existing radiation risks. They can be used by States as a reference for their national regulations in respect of facilities and activities.

The IAEA's Statute makes the safety standards binding on the IAEA in relation to its own operations and also on States in relation to IAEA assisted operations.

The IAEA safety standards also form the basis for the IAEA's safety review services, and they are used by the IAEA in support of competence building, including the development of educational curricula and training courses.

International conventions contain requirements similar to those in the IAEA safety standards and make them binding on contracting parties. The IAEA safety standards, supplemented by international conventions, industry standards and detailed national requirements, establish a consistent basis for protecting people and the environment. There will also be some special aspects of safety that need to be assessed at the national level. For example, many of the IAEA safety standards, in particular those addressing aspects of safety in planning or design, are intended to apply primarily to new facilities and activities. The requirements established in the IAEA safety standards might not be fully met at some existing facilities that were built to earlier standards. The way in which IAEA safety standards are to be applied to such facilities is a decision for individual States.

The scientific considerations underlying the IAEA safety standards provide an objective basis for decisions concerning safety; however, decision makers must also make informed judgements and must determine how best to balance the benefits of an action or an activity against the associated radiation risks and any other detrimental impacts to which it gives rise.

DEVELOPMENT PROCESS FOR THE IAEA SAFETY STANDARDS

The preparation and review of the safety standards involves the IAEA Secretariat and four safety standards committees, for nuclear safety (NUSSC), radiation safety (RASSC), the safety of radioactive waste (WASSC) and the safe transport of radioactive material (TRANSSC), and a Commission on Safety Standards (CSS) which oversees the IAEA safety standards programme (see Fig. 2).

All IAEA Member States may nominate experts for the safety standards committees and may provide comments on draft standards. The membership of the Commission on Safety Standards is appointed by the Director General and

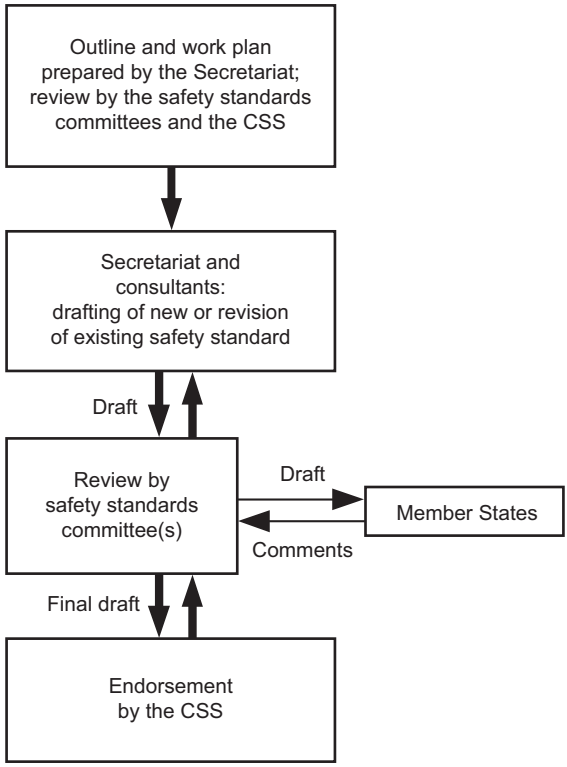

FIG. 2. The process for developing a new safety standard or revising an existing standard.

includes senior governmental officials having responsibility for establishing national standards.

A management system has been established for the processes of planning, developing, reviewing, revising and establishing the IAEA safety standards. It articulates the mandate of the IAEA, the vision for the future application of the safety standards, policies and strategies, and corresponding functions and responsibilities.

INTERACTION WITH OTHER INTERNATIONAL ORGANIZATIONS

The findings of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) and the recommendations of international expert bodies, notably the International Commission on Radiological Protection (ICRP), are taken into account in developing the IAEA safety standards. Some

safety standards are developed in cooperation with other bodies in the United Nations system or other specialized agencies, including the Food and Agriculture Organization of the United Nations, the United Nations Environment Programme, the International Labour Organization, the OECD Nuclear Energy Agency, the Pan American Health Organization and the World Health Organization.

INTERPRETATION OF THE TEXT

Safety related terms are to be understood as defined in the IAEA Safety Glossary (see http://www-ns.iaea.org/standards/safety-glossary.htm). Otherwise, words are used with the spellings and meanings assigned to them in the latest edition of The Concise Oxford Dictionary. For Safety Guides, the English version of the text is the authoritative version.

The background and context of each standard in the IAEA Safety Standards Series and its objective, scope and structure are explained in Section 1, Introduction, of each publication.

Material for which there is no appropriate place in the body text (e.g. material that is subsidiary to or separate from the body text, is included in support of statements in the body text, or describes methods of calculation, procedures or limits and conditions) may be presented in appendices or annexes.

An appendix, if included, is considered to form an integral part of the safety standard. Material in an appendix has the same status as the body text, and the IAEA assumes authorship of it. Annexes and footnotes to the main text, if included, are used to provide practical examples or additional information or explanation. Annexes and footnotes are not integral parts of the main text. Annex material published by the IAEA is not necessarily issued under its authorship; material under other authorship may be presented in annexes to the safety standards. Extraneous material presented in annexes is excerpted and adapted as necessary to be generally useful.

CONTENTS

1. INTRODUCTION

BACKGROUND

1.1. This Safety Guide supports the IAEA Fundamental Safety Principles [1] and the Safety Requirements publications on Safety of Nuclear Power Plants: Commissioning and Operation [2] and Safety Assessment for Facilities and Activities [3]. It supersedes the Safety Guide on Periodic Safety Review of Nuclear Power Plants issued in 2003. Technical terms used in this Safety Guide are defined in the IAEA Safety Glossary [4].

1.2. Routine reviews of nuclear power plant operation (including reviews of modifications to hardware and procedures, significant events, operating experience, plant management and personnel competence) and special reviews following major events of safety significance are the primary means of ensuring safety. In addition, some States have initiated systematic safety reassessments, termed periodic safety review (PSR), to assess the cumulative effects of plant ageing and plant modifications, operating experience, technical developments and siting aspects. A PSR includes an assessment of plant design and operation against applicable current safety standards and operating practices, and has the objective of ensuring a high level of safety throughout the plant's operating lifetime. It is complementary to the routine and special safety reviews conducted at nuclear power plants and does not replace them.

OBJECTIVE

1.3. The purpose of this Safety Guide is to provide recommendations and guidance on the conduct of a PSR for an existing nuclear power plant. This Safety Guide is intended for use by operating organizations, regulatory bodies and their technical support organizations, consultants and advisory bodies.

SCOPE

1.4. This Safety Guide deals with PSR for an operating nuclear power plant. PSR is a comprehensive safety review of all important aspects of safety, carried out at regular intervals, typically every ten years. In addition, a PSR may be used in support of the decision making process for licence renewal or long term operation, or for restart of a nuclear power plant following a prolonged shutdown.

1.5. The review process described in this Safety Guide is valid for nuclear power plants of any age and may have a wider applicability, for example to research reactors and radioactive waste management facilities, by means of a graded approach. However, PSR may not be an appropriate means for identifying safety issues in the decommissioning phase, although the documentation resulting from the PSR of an operating nuclear power plant will be an important input when planning decommissioning.

STRUCTURE

1.6. A rationale for and the objectives of PSR for operating nuclear power plants and general recommendations are provided in Section 2. Long term operation aspects are described in Section 3. Section 4 presents the general review methodology and strategic considerations relating to the conduct of PSR. Section 5 describes the review of safety factors, i.e. the important aspects of safety of an operating nuclear power plant that are addressed in a PSR. Recommendations on global assessment are presented in Section 6. The roles and responsibilities of the operating organization, the regulatory body and external experts when conducting a PSR are set out in Section 7. Section 8 presents a recommended review process. Section 9 deals with post-review activities. Appendix I describes the interfaces between the various safety factors and Appendix II provides recommendations on the content of the various documents and reports relating to PSR. The Annex provides information on typical inputs and outputs in the review of safety factors and lists relevant IAEA and other publications.

2. RATIONALE, OBJECTIVE AND GENERAL RECOMMENDATIONS FOR PERIODIC SAFETY REVIEW

2.1. Since operation of the first generation of commercial nuclear power plants started in the 1950s there have been substantial developments in safety standards and operating practices, and in technology, resulting from new scientific and technical knowledge. Lessons have been learned from operating experience and better analytical methods have been developed. These developments should be considered by operating organizations and regulatory bodies in the interests of continuous safety improvement.

2.2. Requirement 12 of Ref. [2] states:

> "Systematic safety assessments of the plant, in accordance with the regulatory requirements, shall be performed by the operating organization throughout the plant's operational lifetime, with due account taken of operating experience and significant new safety related information from all relevant sources".

Although operating nuclear power plants are subject to routine and special safety reviews, such reviews are generally not sufficiently comprehensive to meet this requirement. For example, routine and special reviews do not always take full account of improvements in safety standards and operating practices, the cumulative effects of plant ageing and modifications, feedback from operating experience and wider developments in science and technology or look forward to planned future operation. Thus, it is common international practice for operating organizations to undertake proactive, strategic, detailed and comprehensive PSRs.

2.3. In many States, PSR forms part of the regulatory system, though the scope and content of the PSR, the manner of its implementation and the regulatory activities relevant to the PSR vary depending on national regulations. PSR provides a means for regulating the safety of plant operation in the long term and for addressing requests by licensees for authorization to continue plant operation beyond an established licensed term or for a further period established by a safety evaluation. A recent PSR can provide reassurance that there continues to be a valid licensing basis taking account of, for example, plant ageing and current safety standards and operating practices.

2.4. PSR provides an effective way to obtain an overall view of actual plant safety and the quality of the safety documentation, and to determine reasonable and practical modifications to ensure safety or improve safety to an appropriate high level. To do this, the PSR needs to identify any lifetime limiting features at the plant in order to plan future modifications and to determine the timing of future reviews.

2.5. On the basis of international experience, it is reasonable to perform a PSR about ten years after the start of plant operation, and then to undertake subsequent PSRs at ten year intervals until the end of operation. Ten years is considered to be an appropriate interval for such reviews in view of the likelihood, within this period, of the following:

— Changes in national and international safety standards, operating practices, technology, underlying scientific knowledge or analytical techniques;
— The potential for the cumulative effects of plant modifications to adversely affect safety or the accessibility and usability of the safety documentation;
— Identification of significant ageing effects or trends;
— Accumulation of relevant operating experience;
— Changes in how the plant is, or will be, operated;
— Changes in the natural, industrial or demographic environment in the vicinity of the plant;
— Changes in staffing levels or in the experience of staff;
— Changes in the management structures and procedures of the plant's operating organization.

2.6. Extension of the period between PSRs beyond about ten years could delay the identification of important safety issues and could lead to a loss of the direct knowledge and experience gained in previous reviews and to a loss of continuity.

2.7. The length of the review process will depend on the availability and retrievability of relevant information and the organizational structure of the operating organization. To provide a timely input, the PSR should be completed within three years, and normally less for the second or subsequent PSRs.

2.8. It is recognized that some States prefer alternative arrangements to a PSR. For example, some States apply routine comprehensive safety assessment programmes that deal with specific safety issues, significant events and changes in safety standards and operating practices as they arise. Such programmes can, if applied with appropriate scope, frequency, depth and rigour, achieve the same outcomes as the process recommended in this Safety Guide. They allow safety to be improved on a continuous basis and avoid the need to implement concurrently a large programme of corrective actions. This Safety Guide is not intended to discourage such alternative arrangements. However, when an alternative approach is followed, it is important that it meets the objectives of PSR (set out in para. 2.9), together with other relevant objectives and requirements of licensing, regulation and operating processes.

2.9. The objective of PSR is to determine by means of a comprehensive assessment:

— The adequacy and effectiveness of the arrangements and the structures, systems and components (equipment) that are in place to ensure plant

safety until the next PSR or, where appropriate, until the end of planned operation (that is, if the nuclear power plant will cease operation before the next PSR is due);
— The extent to which the plant conforms to current national and/or international safety standards and operating practices;
— Safety improvements and timescales for their implementation;
— The extent to which the safety documentation, including the licensing basis, remains valid.

2.10. A PSR can be used for various purposes:

— As a systematic safety assessment carried out at regular intervals, as required by Ref. [2];
— In support of the decision making process for licence renewal;
— In support of the decision making process for long term operation.

GENERAL RECOMMENDATIONS FOR PSR

2.11. The operating organization should have the prime responsibility for ensuring that an adequate PSR is performed.

2.12. A PSR should provide a comprehensive assessment of the safety of the nuclear power plant. Since the complex process of conducting a PSR can be aided by appropriate subdivision of tasks, this Safety Guide sets out these tasks in accordance with 14 safety factors. These safety factors have been selected on the basis of international experience and are intended to cover all aspects important to the safety of an operating nuclear power plant. This subdivision is, however, not unique. In cases where the number of safety factors used and/or their grouping is different (for example, to meet the specific needs of the operating organization or regulatory body or owing to particular aspects of the nuclear power plant under review), the comprehensiveness of the PSR should be ensured by other means.

2.13. The 14 safety factors recommended in this Safety Guide are listed in the following and described in detail in Section 5:

Safety factors relating to the plant

(1) Plant design;
(2) Actual condition of structures, systems and components (SSCs) important to safety;
(3) Equipment qualification;
(4) Ageing.

Safety factors relating to safety analysis

(5) Deterministic safety analysis;
(6) Probabilistic safety assessment;
(7) Hazard analysis.

Safety factors relating to performance and feedback of experience

(8) Safety performance;
(9) Use of experience from other plants and research findings.

Safety factors relating to management

(10) Organization, the management system and safety culture;
(11) Procedures;
(12) Human factors;
(13) Emergency planning.

Safety factors relating to the environment

(14) Radiological impact on the environment.

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

2.14. A review of the physical security of nuclear power plants is generally not included in the PSR because of the sensitivity of the subject and the need to ensure confidentiality. The effectiveness of security arrangements to prevent unauthorized actions that could jeopardize nuclear safety should be reviewed periodically by the appropriate national authorities. Some operating organizations may decide to review physical security as a separate safety factor within the PSR. Guidance on nuclear security measures may be found in publications in the IAEA Nuclear Security Series.

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

— *Positive findings* (that is, strengths): Where current practice is equivalent to good practices as established in current codes and standards, etc.
— *Negative findings* (that is, deviations): Where current practices are not of a standard equivalent to current codes and standards or industry practices, or do not meet the current licensing basis, or are inconsistent with operational documentation for the plant or operating procedures.

2.16. The PSR should address the period until the next PSR or, where appropriate, until the end of planned operation, and should consider whether there are any foreseeable circumstances that could threaten safe operation of the nuclear power plant. If such circumstances are identified, the operating organization should take appropriate action to ensure that the licensing basis remains valid.

2.17. In order to integrate the results of the reviews of individual safety factors, the operating organization should perform a global assessment of safety at the plant. The global assessment should consider all findings and proposed improvements from the safety factor reviews and interfaces between different safety factors.

2.18. The steps of the review should be carried out in four phases, which may overlap or be further subdivided as appropriate:

— Preparation of the PSR project: This should include an agreement with the regulatory body with regard to the scope and timing of the review and the codes and standards that will be used.
— Conduct of the PSR: In this phase, the operating organization should conduct the review in accordance with an agreed ‘basis document’ for the PSR (see para. 4.6). The review should identify findings (which may be positive (strengths) or negative (deviations)) and should lead to proposals for safety improvements and an integrated implementation plan.
— Regulatory review: The regulatory body should review the PSR report prepared by the operating organization and the proposed safety improvements, should identify any issues it wishes to raise (for example, whether further safety improvements need to be considered), should review the proposed integrated implementation plan and should determine whether the licensing basis for the nuclear power plant remains valid.

— Finalization of the integrated implementation plan: The integrated implementation plan, comprising reasonable and practicable safety improvements to be carried out in accordance with a time schedule agreed with the regulatory body, should be finalized in this phase.

The phase following PSR in which the safety improvements are implemented is not considered an activity of PSR and so is not addressed in detail in this Safety Guide. Further details on the various phases of PSR are provided in Section 8.

3. INPUT FROM THE PERIODIC SAFETY REVIEW IN ASSESSING LONG TERM OPERATION OR LICENCE RENEWAL

3.1. Continuation of operation of a nuclear power plant beyond the time frame originally anticipated for its operation (typically 30–40 years) has become a priority for many operating organizations. Long term operation of a nuclear power plant may be defined as operation beyond an established time frame defined, for example, by the licence term, the plant design, relevant standards, or national regulations. Long term operation should be justified by safety assessment, with consideration given to the life limiting processes and features of SSCs important to safety [5–7].

3.2. PSR is considered an effective way to obtain an overall view of actual plant safety, and to determine reasonable and practicable modifications that should be made in order to ensure that a high level of safety is maintained during continued operation. PSR can also be used to identify life limiting features of the plant in order to determine if there is a need to modify, refurbish or replace certain SSCs for the purpose of extending the operating lifetime of the nuclear power plant.

3.3. The intent of this Safety Guide is not to provide recommendations for the activities performed during long term operation of a nuclear power plant. However, a PSR and its findings can be used to support the decision making process for long term operation or licence renewal.

3.4. It is recognized that some States employ alternative arrangements to PSR, which may be equally adequate for justifying extension of the lifetime of a nuclear power plant. In such cases, the necessary plant modifications and related evaluations justifying licence renewal are generally performed separately from each other. If an alternative approach is followed, particular consideration should

be given to the scope and objectives of the safety assessments conducted, which should be agreed with the regulatory body.

3.5. Where the PSR is to be used to support the decision making process prior to entering long term operation (see Ref. [8]), 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.

3.6. In addition, 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 [8].

3.7. If the PSR is to be used to justify long term operation or licence renewal, the entire planned period of long term operation should be considered, and not just the ten years until the next PSR. Furthermore, if long term operation or licence renewal is approved, PSR should continue to be performed in a ten year cycle or at a frequency as required by the national regulatory body.

3.8. Where the PSR is to be used in decision making for long term operation or licence renewal, the review should pay particular attention to the following plant programmes and documentation, as these are of significant importance for continued safe operation:

— Plant programmes to support the safety factors relating to plant design, the actual condition of SSCs important to safety, equipment qualification and ageing;
— A management system that addresses quality management and configuration management;
— Safety analyses involving time limiting assumptions relating to the proposed lifetime;
— Programmes for promoting safety culture focused on the pursuit of excellence in all aspects of safety management and human factors.

3.9. The programmes and documentation listed in para. 3.7 should be properly documented in an updated final safety analysis report for long term operation and/or in other licensing basis documents, and a clear and adequate description

should be provided of the current licensing documents or the current design basis requirements for operation of the nuclear power plant.

3.10. The safety improvements identified in the PSR should be used as inputs to the decision as to whether to approve long term operation.

4. REVIEW OF STRATEGY AND GENERAL METHODOLOGY

4.1. The scope of the PSR should include all safety aspects of a nuclear power plant and should be agreed with the regulatory body. The review should cover all facilities and SSCs on the site covered by the operating licence (including, if applicable, waste management facilities, on-site simulators, etc.) and their operation, together with the operating organization and its staff.

4.2. When performing PSR of a nuclear power plant with several units:

— Aspects such as radiation protection, emergency planning and radiological impact on the environment could be covered in reviews that are common to all units;
— 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.

4.3. The conduct of a generic PSR of multiple standardized units can, by taking advantage of similarities in plant design and operating practice, decrease the resources or effort necessary for PSR. However, a generic PSR should only be conducted for safety factors, or parts of a safety factor, that are similar. If the units are located at different sites or differ in other respects, site specific or unit specific aspects (for example, different design, organizational and human factors aspects) should be reviewed separately.

4.4. The precise approach and the review process (described in detail in Section 5) of the safety factors identified should be customized to the national legal context and relevant regulatory processes. In particular, the list of safety factors (set out in para. 2.13) may be extended (for example, by considering radiation protection or other issues as separate safety factors) or reduced by combining or grouping the safety factors differently.

4.5. Before the review work is started, a number of prerequisites should be satisfied. The main prerequisite is an agreement between the operating organization and the regulatory body as to the scope and objectives of the PSR, including current national and international standards and codes to be used. This agreement is documented in the 'basis document' for the PSR, which should be developed by the operating organization and made subject to approval and/or confirmation by the regulatory body.

4.6. The PSR basis document is an essential instrument that governs the conduct of the PSR and the regulatory review of the PSR results. The basis document should identify the scope, major milestones, including cut-off dates (beyond which changes to codes and standards and new information will not be considered), and methodology of the PSR, the safety factors to be reviewed, the structure of the documentation and the applicable national and international standards, codes and practices. The process for categorizing, prioritizing and resolving findings should also be agreed upon and set out in the basis document.

4.7. 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 State of origin of the technology.

4.8. 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 (ISO) and the International Electrotechnical Commission (IEC)) or, where appropriate, to codes and standards of a recognized organization of a particular State (for example, the American Society of Mechanical Engineers (ASME), the Nuclear Safety Standards Commission (Kerntechnischer Ausschuss), or the Institute of Electrical and Electronics Engineers (IEEE)).

4.9. The practices of international organizations, 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.

4.10. The PSR basis document should outline or reference the project management and quality management 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 (see Appendix II) should comply with the requirements of relevant national or, where appropriate, international standards.

4.11. 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 completion of reviews by the regulatory body. A typical content of a PSR basis document is presented in Appendix II.

4.12. 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 Appendix I.

4.13. Unless otherwise stated in national regulations, the starting point for the PSR should be taken to be the time of the agreement between the operating organization and the regulatory body in the preparation phase (see para. 2.18); the end point of the PSR will be the finalization of the integrated implementation plan.

4.14. International experience suggests that a first PSR at an older nuclear power plant may reveal discrepancies between the design documentation and the actual configuration, or that information on the design basis of SSCs important to safety is incomplete. Where this is the case, the design documentation should be updated and a proper safety justification should be provided (for example, renewal of the obsolete or incomplete final safety analysis report). For modern plants that have been constructed and put into operation with an up to date safety analysis, or for plants with effective configuration management, the effort necessary to conduct a first PSR may be less than that necessary for nuclear power plants where information on the design basis needs to be recovered.

4.15. The effort necessary to carry out a second (or subsequent) PSR of a nuclear power plant will often be considerably reduced compared with that for the first PSR. In general, subsequent PSRs 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).

4.16. 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. Experience has shown that licensees with good configuration management programmes find it easier to perform a PSR.

4.17. In particular, 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 [9]) up to date in light of subsequent modifications, refurbishment and changes to operating, testing, maintenance and other practices.

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

4.19. 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 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.

4.20. As part of the review of each safety factor, all the documents listed in the PSR basis document should be checked for completeness. Experience from Member States has shown that if 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.

4.21. 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 recognize the need to implement safety improvements as soon as reasonable and practicable in accordance with the global assessment of safety at the plant (Section 6). 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 operating organization and should not await completion of the PSR process. Instead, the operating organization should determine prompt corrective actions and, where relevant, submit these without delay to the regulatory body for agreement or approval.

4.22. 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. Section 6 provides further recommendations on the global assessment of safety at the plant.

4.23. If the design basis for the nuclear power plant is not currently documented, the operating organization 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.

4.24. 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 minimize 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.

4.25. Safety improvements should be implemented in accordance with the integrated implementation plan submitted to the regulatory body for agreement or approval. 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.

4.26. 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.

4.27. The risks associated with any unresolved negative findings should be assessed and an appropriate justification for continued operation should be provided. Section 6 provides further recommendations on the content of the global assessment, and on the prioritization and categorization of safety improvements.

4.28. The results of the review should be documented by the operating organization and the documentation should be submitted to the regulatory body either during the PSR or during a structured continuous improvement programme, as required. The documentation should include:

— Reports on the review of each safety factor;
— A report documenting the results of the global assessment;
— 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.

The contents of these documents are described in Appendix II.

5. SAFETY FACTORS IN A PERIODIC SAFETY REVIEW

5.1. The important aspects of safety of an operating nuclear power plant addressed in a PSR are termed 'safety factors'. Fourteen safety factors are identified in this Safety Guide (see para. 2.13), 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 Appendix I and information on typical inputs, outputs and references for each safety factor is given in the Annex. The content of a typical report on the review of each safety factor is set out in Appendix II.

5.2. Radiation protection is not regarded as a separate safety factor in this Safety Guide since it is related to most of the other safety factors. 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 safety; safety performance; and procedures. Alternatively, the operating organization may decide to review radiation protection as a separate safety factor.

5.3. 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.

5.4. 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 operating organization 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 safety that could potentially limit the plant's operating lifetime should be identified to the extent possible.

5.5. The level of detail of the review could vary from safety factor to safety factor. Advice on the methodology that should be applied for each safety factor is provided below. 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.

5.6. 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. The level of effort necessary to review a safety factor will depend on the quality, availability and retrievability of relevant information.

5.7. 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.

5.8. Prior to commencing the review of the various safety factors, methods to assess, categorize, rank and prioritize findings should be established and these methods should be documented (for example, in the review reports).

5.9. The review of safety factors will identify positive and negative findings (see para. 2.15), 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.

5.10. Negative findings should be divided into:

— Deviations for which no reasonable and practicable improvements can be identified;
— Deviations for which identified improvements are not considered necessary;
— Deviations for which safety improvements are considered necessary.

5.11. The approach taken to negative findings should be justified by the operating organization and agreement by the regulatory body should be sought, in accordance with national regulations.

5.12. 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 categorized and prioritized according to their safety significance. The categorization and prioritization of safety improvements may be performed on the basis of deterministic analyses, probabilistic safety assessment, engineering judgement, etc. Safety improvements from the safety factor reviews, together with safety improvements resulting from the global assessment, should be included in the operating organization's integrated implementation plan.

5.13. As stated in para. 4.21, 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 operating organization should take urgent steps to reduce the immediate and significant risk and, where relevant, should submit details of these steps to the regulatory body for agreement or approval.

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

SAFETY FACTORS RELATING TO THE PLANT

Safety factor 1: Plant design

5.15. 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 jeopardize 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

5.16. 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

5.17. 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 jeopardize 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);
  - 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 characterization.
— 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 jeopardize 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.

5.18. Safety requirements for the design, site evaluation and design related aspects are established in Refs [3, 5, 10], and recommendations relating to the safety analysis report are provided in Ref. [9]. Recommendations for the design of radiation protection systems are provided in Refs [11, 12].

Methodology

5.19. 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.

5.20. 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.

5.21. 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 regulatory body.

5.22. 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 operating organization as part of the PSR.

5.23. 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;
— Defence in depth in the design of structures (for example, review of the integrity of fuel, cooling circuit and containment building).

5.24. 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).

5.25. 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. Recommendations on meeting the requirements of Ref. [13] for document control are provided in Ref. [14].

5.26. 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 (for example, in view of its actual condition (see safety factor 2)).

Safety factor 2: Actual condition of SSCs important to safety

5.27. 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

5.28. 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

5.29. 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;
— Verification of the actual state of the SSC against the design basis.

Methodology

5.30. 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.

5.31. Inputs to the review of this safety factor should be made available from the ageing management programme of the operating organization [7]. However, if this programme does not provide adequate information, the necessary inputs should be derived at an early stage of the PSR.

5.32. 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.

5.33. 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.

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

5.35. After determining the actual condition of the SSCs important to safety, each SSC should be assessed against the current design basis (or updated design basis: see safety factor 1) to confirm that design basis assumptions have not been significantly challenged and will remain so until the next PSR.

5.36. 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 3: Equipment qualification

5.37. 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

5.38. 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 [5, 7, 15, 16].

Scope and tasks

5.39. 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.

5.40. Qualification of plant equipment important to safety should be formalized 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 operating organization has the ultimate responsibility for the development and implementation of an adequate plant specific equipment qualification programme.

5.41. 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;
— Protection of qualified equipment from adverse environmental conditions.

Methodology

5.42. 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;
— Quality management provisions that ensure that an effective qualification programme is in place.

5.43. 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);
— 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.

5.44. 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 (see safety factor 2). 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 4: Ageing

5.45. 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

5.46. 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

5.47. 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;
— Record keeping.

5.48. The review should evaluate the following technical aspects:

— Ageing management methodology [7];
— The operating organization'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;
— Obsolescence of technology used in the nuclear power plant.

Methodology

5.49. 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.

5.50. The review should examine whether effective control of ageing degradation is achieved by means of a systematic ageing management process in accordance

with the requirements established in Refs [2, 5], and the recommendations provided in Ref. [7]. 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 minimizing the rate of ageing degradation;
— Inspection and monitoring consistent with the applicable requirements with the aim of timely detection and characterization 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;
— Maintenance (that is, repair or replacement of parts) to prevent or remedy unacceptable ageing degradation.

5.51. 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;
— The ageing management programme will ensure continued safe operation for at least the period until the next PSR.

SAFETY FACTORS RELATING TO SAFETY ANALYSIS

Safety factor 5: Deterministic safety analysis

5.52. 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

5.53. 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);
— The existence and adequacy of safety margins.

Scope and tasks

5.54. 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, in the State or in other States;
— 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;
— 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.

Safety requirements relevant for the review of deterministic safety analysis are established in Refs [3, 5], and recommendations are provided in Ref. [17].

Methodology

5.55. 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.

5.56. 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 standard.

5.57. 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.

5.58. 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.

5.59. 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.

5.60. 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 6: Probabilistic safety assessment

5.61. A review of the probabilistic safety assessment (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

5.62. 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;
— Whether the existing scope and application of PSA are sufficient.

Scope and tasks

5.63. 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 PSA show that risks are sufficiently low and well balanced for all postulated initiating events and operational states, and meet relevant probabilistic safety criteria;

— 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.

Safety requirements relevant for the review of PSA are established in Refs [3, 5] and recommendations are provided in Refs [18, 19].

Methodology

5.64. 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 regulatory body.

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

5.66. 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.

5.67. 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.

5.68. 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.

5.69. 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.

5.70. 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.

5.71. 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 regulatory body.

5.72. 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 7: Hazard analysis

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

Objective

5.74. 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

5.75. 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;
— The appropriateness of procedures to cover operator actions claimed to prevent or mitigate the hazard.

5.76. 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 externals hazards has already been established, this should be reviewed for completeness.

5.77. 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;
— Loss or low capacity of air conditioning (which may lead to high temperatures).

5.78. The following representative external hazards that may affect plant safety should be reviewed (additional site specific internal 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, external missiles;
— Explosion;
— Biological fouling;
— Lightning strike;
— Electromagnetic or radio frequency interference;
— Vibration;
— Traffic;
— Loss of internal and external services (cooling water, electricity, etc.).

Methodology

5.79. 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.

5.80. 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 [17]. Amongst 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.

5.81. 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, both in the State and in other States.

5.82. 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.

5.83. 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 (Refs [20–26]). The adequacy of the preventive and mitigatory measures can be evaluated by deterministic safety analysis (safety factor 5) or PSA (safety factor 6).

SAFETY FACTORS RELATING TO PERFORMANCE AND FEEDBACK OF EXPERIENCE

Safety factor 8: Safety performance

5.84. 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

5.85. 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

5.86. 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;
— Compliance with regulatory requirements.

5.87. The review of safety performance is closely linked to the review of the use of experience from other plants and research findings (safety factor 9), but the review of safety performance should be restricted to operating experience at the plant under review.

5.88. 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 in the State or in other States.

5.89. 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.

5.90. 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 examine specifically 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 in the State or in other States.

5.91. Data on the generation of radioactive waste should be reviewed to determine whether operation of the plant is being optimized to minimize 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

5.92. Where available, the review should utilize 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 sets of safety performance indicators developed by the IAEA, by certain Member States and by WANO could be used for this purpose. References [27, 28] provide recommendations and guidance on the use of safety indicators for verifying compliance with the requirements for safe plant operation established in Ref. [2]. Reference [2] requires that the operating experience at the plant be evaluated in a systematic way and that operating experience be used as an input to the PSR.

5.93. 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.

5.94. 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;
— Implementation of corrective actions following events.

5.95. 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.

5.96. 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.

5.97. Reference [2] 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. References [29, 30] 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.

5.98. The PSR should include a review of the effectiveness of the operating organization's process for the routine evaluation of operating experience. However, where a common process is applied by the operating organization 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 (see para. 4.3 for further details). Reference [31] provides detailed recommendations on reviewing the effectiveness of the process for the feedback of operating experience.

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

5.100. 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.

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

5.102. 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 summarized (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 9: Use of experience from other plants and research findings

5.103. 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. Reference [2] requires the operating organization 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

operating organization is responsible and wider experience in the State and in other States, including relevant information from non-nuclear facilities.

Objective

5.104. 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 in the operating organization [31, 32].

Scope and tasks

5.105. The review should identify operating experience reports and other information that may be important to nuclear safety at other plants owned by the operating organization, together with relevant experience and national and international research findings from nuclear and non-nuclear facilities both in the State and in other States. 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.

5.106. The review of this safety factor is closely related to the review of safety performance (safety factor 8). 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

5.107. 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;
— Review the processes for assessing and, if necessary, implementing research findings and findings from operating experience relevant to safety.

5.108. Arrangements have been established for the dissemination of operating experience at nuclear power plants by the IAEA, the Nuclear Energy Agency of the OECD (OECD/NEA), WANO, the Institute of Nuclear Power Operations (INPO) and various plant owners' groups. The operating organization 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.

5.109. 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.

5.110. For an operating organization 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, provided that these take account of the criteria for such reviews set out in para. 4.3.

SAFETY FACTORS RELATING TO MANAGEMENT

Safety factor 10: Organization, the management system and safety culture

5.111. The operating organization 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 organization 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

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

Scope and tasks

5.113. The review of the organization and management system should include a review of the following elements or programmes against national and international standards:

— Policy statements of the operating organization;
— 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;
— The processes and supporting information that explain how work is to be specified, prepared, reviewed, performed, recorded, assessed and improved.

5.114. In addition, the review of the organization and management system should verify the following:

— There are adequate processes in place for managing organizational 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 specialized staff.
— There are adequate processes in place for feedback of operating experience to the staff, including experience relating to organizational 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.

5.115. 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 organization;
— 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 organization 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 prioritization 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 organizational structure and managing changes in accountability for matters affecting safety;

— Verification that there is adequate training in safety culture, particularly for managers.

The requirements established in Ref. [13] and recommendations provided in Refs [14, 33–35], together with Refs [36–40], should be considered in carrying out the tasks listed above.

Methodology

5.116. Regular and systematic reviews of the management system are necessary to ensure that the safety policies, goals and objectives of the organization are being met as required. These reviews should include evaluation of how the tasks indicated in para. 5.115 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.

5.117. 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 operating organization and its processes;
— Non-conformances and corrective and preventive actions;
— Lessons learned from other organizations;
— Opportunities for improvement.

5.118. 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.

5.119. Where the scope of the regular management system reviews has not addressed any of the aspects listed in para. 5.117, the PSR should undertake a detailed review of the omitted tasks.

5.120. An assessment of safety culture could include interviews of personnel at all levels of the operating organization and personnel providing support services.

In such cases, the review team should include behavioural scientists to carry out the safety culture assessment.

Safety factor 11: Procedures

5.121. 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).

5.122. References [2, 5] establish requirements for operating procedures and Refs [23, 24, 27, 33, 41, 42] provide relevant recommendations and guidance.

Objective

5.123. The objective of the review of procedures is to determine whether the operating organization'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

5.124. 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;
— Procedures for management of radioactive effluents and waste.

Methodology

5.125. 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 categorization 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.

5.126. 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 12: Human factors

5.127. 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 operating organization 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

5.128. 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

5.129. 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;
— Adequate facilities and programmes are available for staff training.

5.130. 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;
— Clarity and achievability of procedures.

Further recommendations and guidance on assessment of human factors can be found in Refs [33–36, 43].

Methodology

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

5.132. 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 operating organization may decide that specific elements of the review should be carried out by external consultants.

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

5.134. 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 13: Emergency planning

5.135. The design and operation of a nuclear power plant are required to prevent or otherwise minimize 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 operating organization but also for local and national authorities.

Objective

5.136. The objective of the review of emergency planning is to determine: (a) whether the operating organization has in place adequate plans, staff, facilities and equipment for dealing with emergencies; and (b) whether the operating organization's arrangements have been adequately coordinated with the arrangements of local and national authorities and are regularly exercised.

Scope and tasks

5.137. 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.

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

5.139. 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 organizations 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;
— Evaluate the effects of any recent residential and industrial developments around the site.

5.140. Reference [44] establishes requirements and Refs [45–50] provide relevant recommendations and information for emergency preparedness for and response to a nuclear or radiological emergency.

Methodology

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

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

5.143. 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.

5.144. 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.

5.145. Arrangements for regular reviews of emergency plans and procedures and their periodic updating can be evaluated as part of the review of the operating organization's management processes (safety factor 11).

SAFETY FACTOR RELATING TO THE ENVIRONMENT

Safety factor 14: Radiological impact on the environment

5.146. The operating organization 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

5.147. The objective of the review of this safety factor is to determine whether the operating organization 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

5.148. 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 operating organization, with account taken of relevant factors external to the nuclear power plant.

5.149. 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 regulatory body for information.

Methodology

5.150. 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.

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

5.152. As part of the review it should be verified that:

— Concentrations of radionuclides in air, water (including river water, sea water and groundwater), soil, agricultural and marine products and animals are being monitored by the operating organization or by an independent public organization 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 recognized by the operating organization;
— 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;
— Changes in the use of areas around the site have been taken into account in the development of monitoring programmes.

5.153. 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.

6. GLOBAL ASSESSMENT

6.1. 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 operating organization) 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.

6.2. 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.

6.3. An analysis of the interfaces between the various safety factors (see Appendix I) 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 [1].

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

6.5. 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.

6.6. 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.

6.7. A method for assessing, categorizing, ranking and prioritizing 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, PSA, engineering judgement, cost benefit analysis and/or risk analysis (see para. 6.10) or a combination thereof. The safety improvements proposed in the global assessment should be included in the integrated implementation plan.

6.8. 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.

6.9. Although negative findings may be individually acceptable, their combined effects should also be reviewed for acceptability. This is particularly relevant when considering human and organizational 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).

6.10. As part of the global assessment, the following matters should be examined:

— 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 regulatory body.
— 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.
— 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.

6.11. 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 Ref. [51].

6.12. 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 Appendix II). The safety improvements should be included in the integrated implementation plan and then implemented according to a time schedule agreed with the regulatory body.

7. ROLES AND RESPONSIBILITIES

7.1. The responsibility for conducting the PSR, if required to be performed, and reporting its findings lies solely with the operating organization of the plant. The operating organization should report all safety significant findings from the PSR to the regulatory body, subject to national regulations.

7.2. Depending on national regulations, the regulatory body has the responsibility for:

— Specifying or approving the requirements to perform the PSR;
— Approving the documentation to be provided by the operating organization prior to the PSR (i.e. the PSR basis document including the project plan);
— Reviewing the actual scope, conduct and findings of the PSR and the resulting safety improvements;
— Assessing the prospects for safe operation for the period until the next PSR;
— Taking appropriate licensing actions;
— Informing the government and the general public about the results of the PSR and resulting safety improvements.

7.3. Both the operating organization and the regulatory body should have sufficient technical competence to discharge their responsibilities set out in paras 7.1 and 7.2. This should include competence to manage effectively any contracted work (for example, from external consultants or technical support organizations) and to assess the outputs produced.

7.4. Certain aspects of the PSR can be carried out more effectively by external consultants. For example, the review of the safety factor relating to organization, the management system and safety culture, and the safety factor relating to human factors could benefit from reviews carried out by specialists completely independent from the organization operating the plant. The operating organization should seek to identify aspects of the PSR where external consultants might be better placed than internal staff to carry out an impartial, independent and objective review, noting that the engagement of external organizations does not

diminish the responsibility of the operating organization for carrying out an adequate PSR.

8. THE REVIEW PROCESS

INTRODUCTION

8.1. The overall process for undertaking the PSR of a nuclear power plant is shown in Fig. 1. The process consists of parallel but independent activities of the operating organization (shown in Figs 2–4) and of the regulatory body (shown in Fig. 5). Major interactions between the operating organization and the regulatory body in particular occur during the assessment of PSR reports (see para. 8.32).

8.2. The activities of the operating organization can be divided into three steps:

(1) Preparation for the PSR project;
(2) Conduct of the reviews of safety factors;
(3) Analysis of the findings (including the global assessment), and preparation of a programme of safety improvements.

8.3. The regulatory body's activities are carried out throughout the PSR project. This section provides guidance on the various activities of the operating organization and the regulatory body. The review process described is intended to be sufficiently flexible to allow its modification for compliance with national regulations and to facilitate the use of findings of relevant studies and routine or special safety reviews.

8.4. The starting point of a PSR is the agreement between the operating organization and the regulatory body on the general scope and requirements for the PSR, and its expected outcome, as described in the basis document. As part of this agreement, the operating organization and the regulatory body 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.

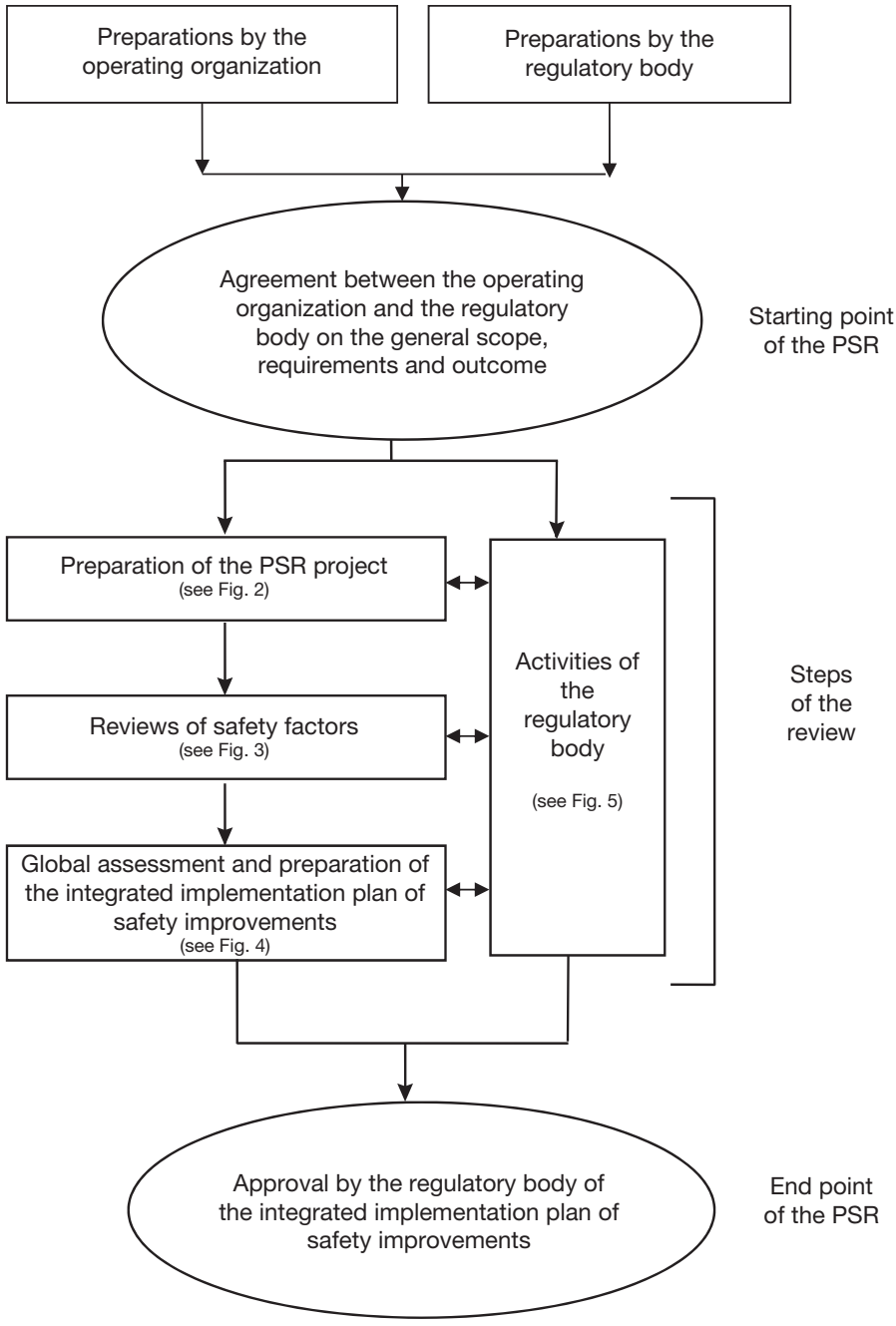

FIG. 1. Overall process for a PSR of a nuclear power plant.

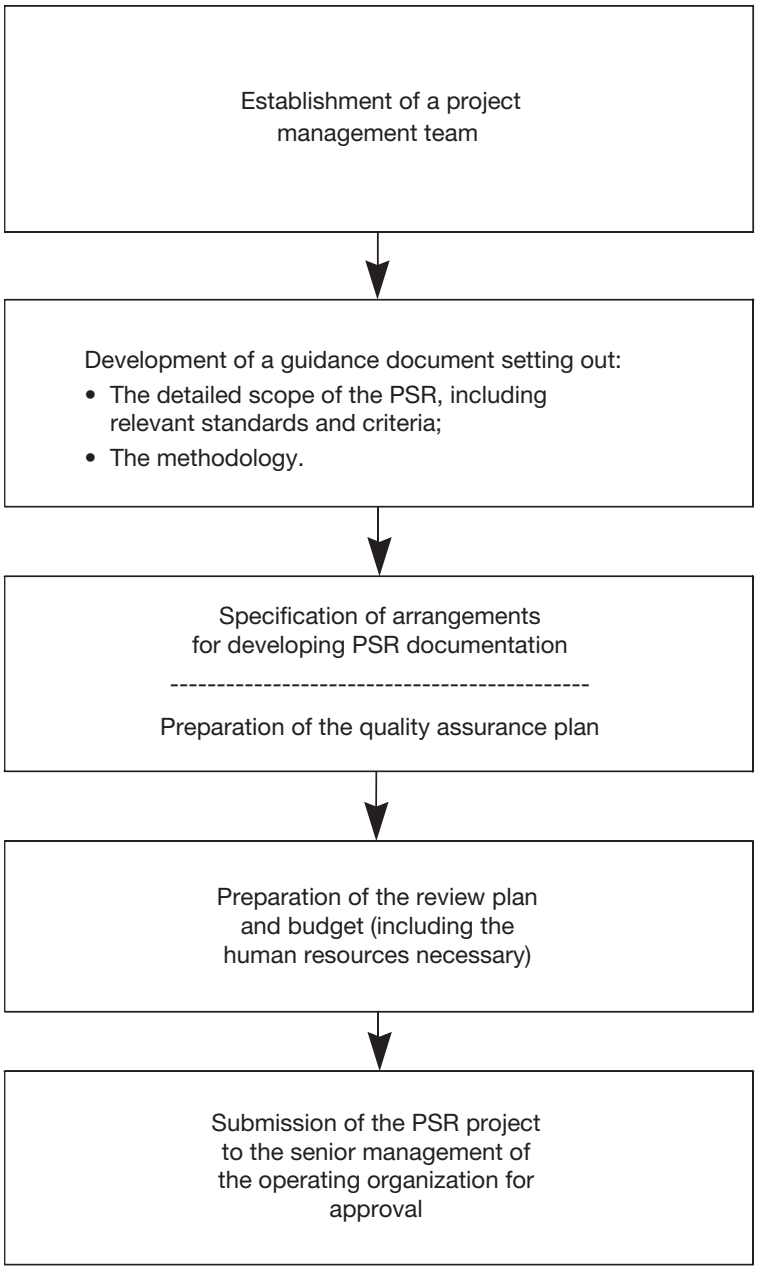

FIG. 2. Process for the preparation of the project for the PSR.

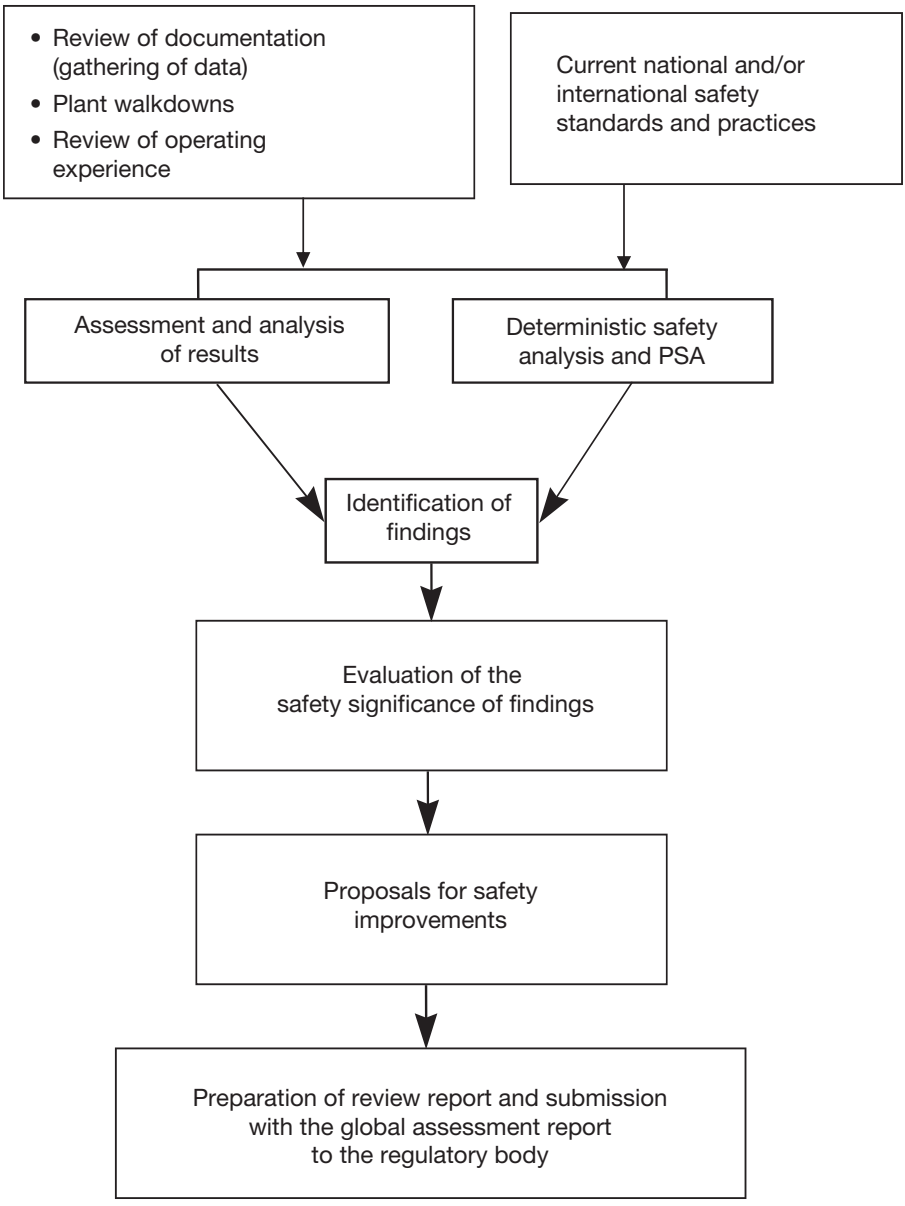

FIG. 3. Process for the review of each safety factor.

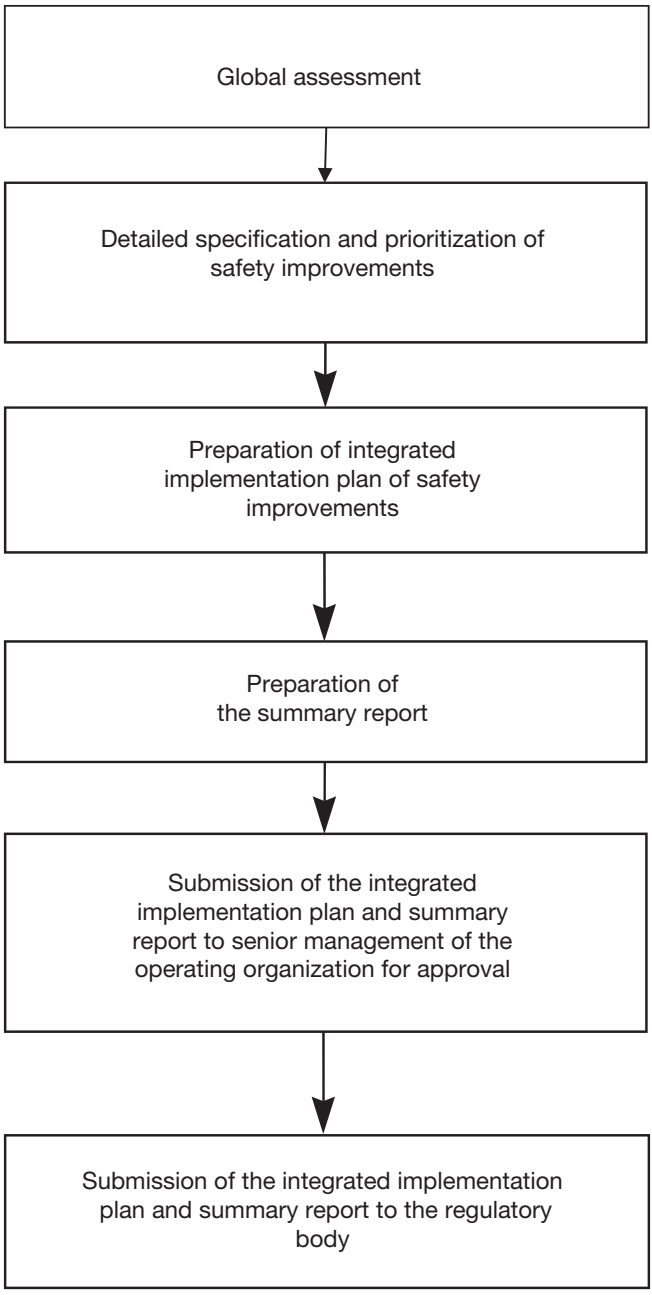

FIG. 4. Process for global assessment and preparation of the integrated implementation plan of safety improvements.

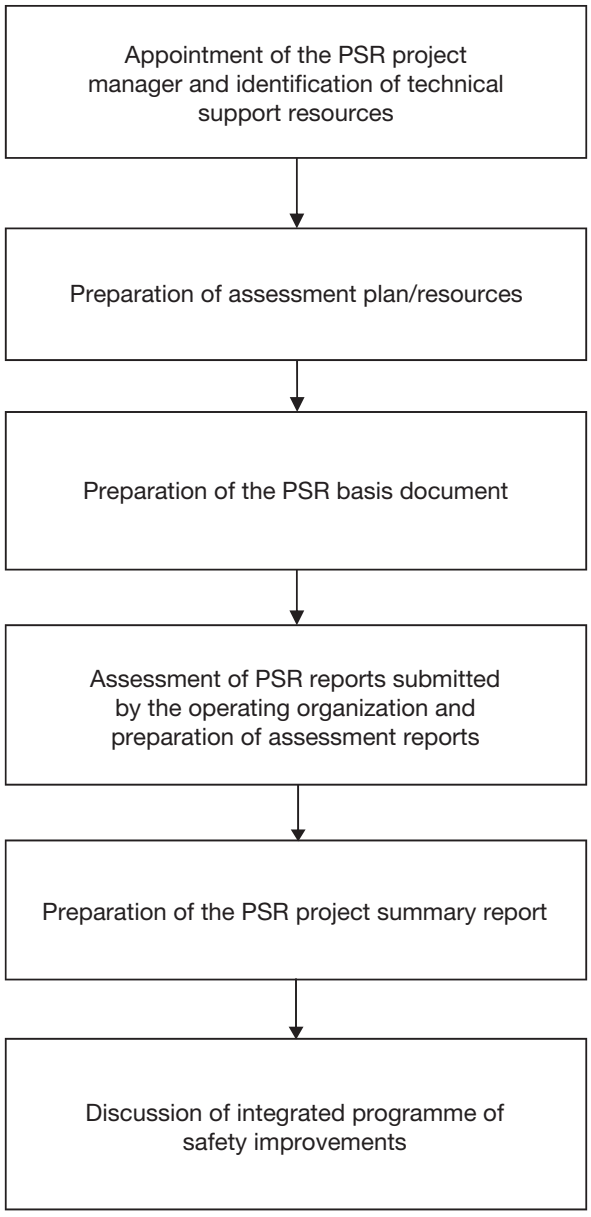

FIG. 5. Activities of the regulatory body.

ACTIVITIES OF THE OPERATING ORGANIZATION

Preparation of the PSR project

8.5. An appropriate project management team should be established and a reasonable time schedule should be developed at the outset of the project. This is necessary in order to complete the PSR within the agreed time schedule and budget.

8.6. 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.

8.7. An overall budget for the PSR should be determined, which takes account of the scope of the review, organizational aspects, the need to employ external organizations and the schedule for the PSR. Review activities that will require intensive resources should be identified and their scope and depth should be taken into account in the overall budget.

8.8. A PSR is typically performed by a number of review teams that work in parallel. A document should therefore 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.

8.9. To ensure the appropriate quality and format of the PSR documents, a quality assurance plan should be prepared that, among other things, defines the requirements for the preparation and verification of the PSR 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.

8.10. Before the reviews of safety factors commence, senior management from the operating organization should review the time schedule and budget for approval.

8.11. A PSR is a complex undertaking involving non-routine work by many of the staff of the operating organization and external technical support organizations.

Therefore, appropriate training and briefings should be carried out to facilitate the effective and efficient completion of the PSR.

Review of safety factors

8.12. 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. It is not always possible to include all the input information needed for PSR in such databases.

8.13. A review of each safety factor should be carried out (see Section 5) 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).

8.14. 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 (see Section 5). 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.

8.15. If the operating organization 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.

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

8.17. A safety factor report should be prepared to summarize the results of the review of each safety factor (see Appendix II).

8.18. A global assessment should then be performed and a report of the global assessment should be prepared (see Section 6 and Appendix II).

8.19. A final PSR report should be prepared to include the following:

— 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);
— A summary of the outcomes from the global assessment;
— An integrated implementation plan of proposed safety improvements, including their safety significance and prioritization.

Preparation of the integrated implementation plan of safety improvements

8.20. The safety improvements and the integrated implementation plan proposed in the final PSR report should be updated after the final PSR report has been discussed with the regulatory body. 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, prioritization and timing.

8.21. 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 recognized 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.

8.22. For PSRs performed for multiple standardized units, the integrated implementation plan could be executed in stages. However, this should be justified by the operating organization and, if required, made subject to regulatory body approval.

8.23. The integrated implementation plan should be subject to approval by senior managers from the operating organization, who should commit the necessary human and financial resources to implement the proposed safety improvements according to a reasonable and practicable schedule. The approved plan should then be submitted to the regulatory body for review and, if required, for approval, in accordance with national requirements and regulations.

8.24. A summary report should be prepared to present the highlights of the PSR review process. This summary report could be shared with members of the public, depending on national regulations.

ACTIVITIES OF THE REGULATORY BODY

8.25. The requirements for the PSR should be established by the regulatory body.

8.26. Milestones and time frames provided by the operating organization should be reviewed by the regulatory body for approval, if this is required.

8.27. The regulatory body should appoint a project manager for assessment of the PSR. The responsibilities of the project manager should include:

— Coordination of all PSR related activities within the regulatory body (and any external sources of assistance);
— Acting as a focal point for communication with the operating organization.

8.28. The regulatory body should assess the PSR basis document provided by the operating organization and should agree to the format and content of the proposed PSR with the operating organization.

8.29. An assessment plan should be prepared by the regulatory body for performing the regulatory assessment of the PSR reports. The plan should state the assessment criteria to be used, and should identify the source and availability of the technical experts who will carry out the regulatory assessments.

8.30. Appropriate training and briefings of the reviewers should be carried out to ensure that consistent criteria are applied and to facilitate the effective and efficient completion of the regulatory assessment.

8.31. The regulatory body should review the PSR reports and should assess the PSR findings and proposals for safety improvements submitted by the operating organization. To do this, the regulatory body may use its own analysis methods and verification and validation calculations, for example, using alternative computer codes.

8.32. During the assessment process, the regulatory body and/or its technical support staff should communicate with the operating organization to clarify issues, including discussion of any additional issues identified by the assessor,

and to acquire any necessary additional information. The results of these interactions should be documented for future reference.

8.33. Assessors should prepare reports that identify clearly all significant issues that need to be resolved. Such assessment reports could also give an initial indication of the acceptability of safety improvements proposed by the operating organization.

8.34. In the event that the PSR identifies a finding that poses an immediate and significant risk to the health and/or safety of workers or the public or to the environment, the regulatory body should verify that the operating organization takes prompt action and does not wait until the end of the PSR before taking corrective action or implementing safety improvements.

8.35. Using the individual assessment reports, the regulatory body (usually the PSR project manager) should prepare an integrated project report. The integrated project report should present, in a concise way, the following:

— The regulatory body's view of the adequacy of the PSR as documented in the reports submitted, including the safety improvements already implemented by the operating organization;
— The regulatory body's view of the adequacy of safety improvements identified by the operating organization but not yet implemented;
— An evaluation of the time schedule for the integrated implementation plan proposed by the operating organization.

8.36. The regulatory body should discuss the integrated project report with the operating organization. This may involve several meetings, but should lead to an agreement from both parties on an updated integrated implementation plan of safety improvements. The regulatory body should then take appropriate licensing or other regulatory action consistent with national regulation.

9. POST-REVIEW ACTIVITIES

9.1. Implementation of identified reasonable and practicable safety improvements in a timely manner is a critically important activity. Therefore, both the operating organization and the regulatory body should maintain adequate arrangements for project management after the completion of the PSR. These arrangements should ensure that the regulatory body is notified when

safety improvements are implemented and is notified of any significant delays in completing the improvements later than the agreed time schedule.

9.2. All PSR documentation should be stored using a suitable system to allow easy retrieval and examination, by both the operating organization and the regulatory body. The documentation should contain the final versions of the PSR documents and information on lessons learned from the PSR.

9.3. The outcomes of the PSR and the resulting safety improvements will often necessitate changes to plant documentation. Therefore, the operating organization 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.

9.4. Similarly, 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 operating organization should modify all affected documentation (for example, manuals relating to the operating organization, the emergency plan, training plans) as necessary.

9.5. Where a final safety analysis report is part of the documentation of the nuclear power plant, this should be updated after completion of the PSR to reflect the results of reviews of reference documents and requirements and to take account of 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.

9.6. The operating organization and/or the regulatory body should report the outcomes of the PSR to the government where required in accordance with national regulations, customs and practice. In certain States, communication of the results of the PSR to the general public is considered to be a good practice.

Appendix I

INTERFACES BETWEEN SAFETY FACTORS

I.1. The teams reviewing each safety factor should communicate with each other during the review process, starting from the preparation phase of the PSR. Communication between review teams should be well organized, because findings (or outputs) identified in the review of one safety factor could be an important input to the review of other safety factors. All findings that are related to other safety factors should be provided immediately to the reviewers of the relevant safety factors. Potential likely correlations between the different safety factors are shown in Table 1. The safety factors listed on the upper horizontal axis may provide input to the safety factors listed on the vertical axis on the left.

TABLE 1. MATRIX OF INTERFACES BETWEEN SAFETY FACTORS

Safety factors receiving input	Safety factors providing input													
	SF1	**SF2**	**SF3**	**SF4**	**SF5**	**SF6**	**SF7**	**SF8**	**SF9**	**SF10**	**SF11**	**SF12**	**SF13**	**SF14**
SF 1		X	X	X	X	X	X	X	X			X	X	X
SF 2	X		X	X	X			X	X	X				
SF 3	X	X		X	X	X	X	X	X	X			X	
SF 4	X	X	X		X	X	X	X	X	X	X			
SF 5	X	X	X	X		X		X	X		X	X	X	
SF 6	X	X	X	X	X		X	X	X		X	X	X	
SF 7	X	X	X		X	X		X	X		X	X	X	X
SF 8	X	X			X	X	X		X	X	X	X		X
SF 9	X									X	X			X
SF 10		X			X	X		X	X		X	X		X
SF 11	X	X	X	X	X	X	X	X	X	X		X	X	X
SF 12	X	X	X	X	X	X	X	X	X	X	X			
SF 13	X				X	X	X	X	X		X			
SF 14	X	X				X		X	X		X			

SF 1: Plant design.
SF 2: Actual condition of SSCs important to safety.
SF 3: Equipment qualification.
SF 4: Ageing.
SF 5: Deterministic safety analysis.
SF 6: Probabilistic safety assessment.
SF 7: Hazard analysis.
SF 8: Safety performance.
SF 9: Use of experience from other plants and research findings.
SF 10: Organization, the management system and safety culture.
SF 11: Procedures.
SF 12: Human factors.
SF 13: Emergency planning.
SF 14: Radiological impact on the environment.

Appendix II

DOCUMENTATION OF THE PSR

II.1. The following documents should be produced during the conduct of the PSR to provide the information required by different stages of the process described in this Safety Guide:

— The basis document for the PSR;
— Safety factor report(s);
— The global assessment report;
— The final PSR report, including the integrated implementation plan.

Recommended contents of the PSR basis document

II.2. The PSR basis document should include three main parts:

(1) 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, categorizing, prioritizing 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;
— 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;
- The final PSR report, including the integrated implementation plan of safety improvements.

(2) Safety factors

The following information should be provided for each safety factor:

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

(3) Project plan for the PSR

— Organization of the project, including roles and responsibilities;
— Time schedule including any major milestones and cut-off dates;
— Project and quality management processes;
— Processes for ensuring consistency between separate safety factor reviews, for example, for establishing a common set of technical databases (see para. 8.12);
— Training;
— Internal communications;
— The plan for communicating and interfacing with and gaining relevant approvals and agreements from, the regulatory body.

Recommended contents of each safety factor report

II.3. 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. In some States, 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.

II.4. 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 (for example, organizational capability, see para. 5.4);
— 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 prioritization;
— Review of future safety for the period addressed in the PSR;
— Conclusions;
— References;
— Appendices.

Recommended contents of the global assessment report

II.5. 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;
— Justification for proposed continued operation in both the short term and long term (see para. 6.8).

Recommended contents of the final PSR report

II.6. 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;
— An assessment of the safety of future plant operation over the period addressed in the PSR.

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Annex

TYPICAL INPUTS, OUTPUTS AND RELEVANT PUBLICATIONS FOR THE REVIEW OF SAFETY FACTORS

SAFETY FACTOR 1: PLANT DESIGN

Inputs	Outputs
Standards and requirements: — Current national and international requirements and codes and standards on design and site evaluation; — 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; — Review compliance with plant design specifications. Operating experience: — Operating experience from similar plants in the State and in other States; — Actual physical condition of the plan. The review of this safety factor may require input from other safety factors (see Appendix I), 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; — New postulated initiating events and new technical solutions.	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 jeopardize 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; — 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 Appendix I), for example in the following areas: — New safety margins; — Plant design modifications.

RELEVANT IAEA PUBLICATIONS

Application of the Management System for Facilities and Activities, IAEA Safety Standards Series No. GS-G-3.1, IAEA, Vienna (2006).

Design of Emergency Power Systems for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-1.8, IAEA, Vienna (2004).

Design of Fuel Handling and Storage Systems in Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-1.4, IAEA, Vienna (2003).

Design of Reactor Containment Systems for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-1.10, IAEA, Vienna (2004).

Design of the Reactor Coolant System and Associated Systems in Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-1.9, IAEA, Vienna (2004).

Design of the Reactor Core for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-1.12, IAEA, Vienna (2005).

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Safety Assessment for Facilities and Activities, IAEA Safety Standards Series No. GSR Part 4, IAEA, Vienna (2009).

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Seismic Design and Qualification for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-1.6, IAEA, Vienna (2003).

Seismic Hazards in Site Evaluation for Nuclear Installations, IAEA Safety Standards Series No. SSG-9, IAEA, Vienna (2010).

Site Evaluation for Nuclear Installations, IAEA Safety Standards Series No. NS-R-3, IAEA, Vienna (2003).

Software for Computer Based Systems Important to Safety in Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-1.1, IAEA, Vienna (2000).

The Management System for Facilities and Activities, IAEA Safety Standards Series No. GS-R-3, IAEA, Vienna (2006).

SAFETY FACTOR 2: ACTUAL CONDITION OF SYSTEMS, STRUCTURES AND COMPONENTS

Inputs	Outputs
Standards and requirements: — Current national and international requirements, codes and standards on design; — Appropriate standards on assessment; — Operating experience from plants, both in the State and in other States, 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; — 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; — Records of modifications. The review of this safety factor may require input from other safety factors (see Appendix I), for example in the following areas: — Negative findings from equipment qualification; — Predictions of ageing, effectiveness of the ageing management programme; — New postulated initiating events; — New internal and external hazards; — Operating history; — Configuration management.	Examples of findings from the review of the actual condition of the plants 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 needs to be improved; — Processes do not maintain adequate records of the actual state of the plant, ageing processes and obsolescence of components; — 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 Appendix I).

SAFETY FACTOR 3: EQUIPMENT QUALIFICATION

Inputs	Outputs
Standards and requirements: — Current national and international requirements and standards on design and site evaluation; — 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); — Records of all qualification measures taken during the installed service life of the equipment. Operating experience: — Operating experience from similar plants in the State and in other States The review of this safety factor may require input from other safety factors (see Appendix I).	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; — 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; — Improvements to the ageing management programme. Results from the review of this safety factor may provide inputs for other safety factors (see Appendix I).

RELEVANT IAEA PUBLICATIONS

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Equipment Qualification in Operational Nuclear Power Plants: Upgrading, Preserving and Reviewing, Safety Reports Series No. 3, IAEA, Vienna (1998).

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Seismic Design and Qualification for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-1.6, IAEA, Vienna (2003).

SAFETY FACTOR 4: AGEING

Inputs	Outputs
Standards and requirements: — Current national and international ageing management standards; — Relevant guidance on the management of plant ageing and record keeping. Plant specific documents: — Manuals on ageing management used by the operating organization; — 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; — 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 Appendix I), 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; — Plant design review. Examples of outputs are: — Proposals for replacement of particular SSCs important to safety; — Improvements to the maintenance programme; — Improvements to the ageing management programme. Results from the review of this safety factor may provide inputs for other safety factors (see Appendix I).

RELEVANT IAEA PUBLICATIONS

Ageing Management for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-2.12, IAEA, Vienna (2009).

AMAT Guidelines: Reference Document for the IAEA Ageing Management Assessment Teams (AMATs), IAEA Services Series No. 4, IAEA, Vienna (1999).

Data Collection and Record Keeping for the Management of Nuclear Power Plant Ageing, Safety Series No. 50-P-3, IAEA, Vienna (1992).

Implementation and Review of a Nuclear Power Plant Ageing Management Programme, Safety Reports Series No. 15, IAEA, Vienna (1999).

Methodology for the Management of Ageing of Nuclear Power Plant Components Important to Safety, Technical Reports Series No. 338, IAEA, Vienna (1992).

Periodic Safety Review of Nuclear Power Plants: Experience of Member States, IAEA-TECDOC-1643, IAEA, Vienna (2010).

Proactive Management of Ageing for Nuclear Power Plants, Safety Reports Series No. 62, IAEA, Vienna (2009).

Safe Long Term Operation of Nuclear Power Plants, Safety Reports Series No. 57, IAEA, Vienna (2008).

Safety of Nuclear Power Plants: Commissioning and Operation, IAEA Safety Standards Series No. SSR-2/2, IAEA, Vienna (2011).

Safety of Nuclear Power Plants: Design, IAEA Safety Standards Series No. SSR-2/1, IAEA, Vienna (2012).

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; — 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 Appendix I).	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; — 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 Appendix I).

RELEVANT IAEA PUBLICATIONS

Deterministic Safety Analysis for Nuclear Power Plants, IAEA Safety Standards Series No. SSG-2, IAEA, Vienna (2009).

Implementation of Accident Management Programmes in Nuclear Power Plants, Safety Reports Series No. 32, IAEA, Vienna (2004).

Safety Assessment and Verification for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-1.2, IAEA, Vienna (2002).

Safety Assessment for Facilities and Activities, IAEA Safety Standards Series No. GSR Part 4, IAEA, Vienna (2009).

Safety of Nuclear Power Plants: Design, IAEA Safety Standards Series No. SSR-2/1, IAEA, Vienna (2012).

Severe Accident Management Programmes for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-2.15, IAEA, Vienna (2009).

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); — 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 Appendix I).	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; — Improvements to the PSA reliability database. Results from the review of this safety factor may provide inputs for other safety factors (see Appendix I).

RELEVANT IAEA AND OECD/NEA PUBLICATIONS

Deterministic Safety Analysis for Nuclear Power Plants, IAEA Safety Standards Series No. SSG-2, IAEA, Vienna (2009).

Development and Application of Level 1 Probabilistic Safety Assessment for Nuclear Power Plants, IAEA Safety Standards Series No. SSG-3, IAEA, Vienna (2010).

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Procedures for Conducting Probabilistic Safety Assessments of Nuclear Power Plants (Level 3), Safety Series No. 50-P-12, IAEA, Vienna (1996).

Safety Assessment for Facilities and Activities, IAEA Safety Standards Series No. GSR Part 4, IAEA, Vienna (2009).

Safety of Nuclear Power Plants: Design, IAEA Safety Standards Series No. SSR-2/1, IAEA, Vienna (2012).

SAFETY FACTOR 7: HAZARD ANALYSIS

Inputs	Outputs
Standards and requirements: — Current national and international design codes, safety assessment standards and safety guides; — National regulations; — Control procedures, safety assessment standards and safety guides of the operating organization. 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; — Records of hydrological hazards. Operating experience — Operating experience from similar plants or sites, both in the State and in other States; — Records of hazard incidents affecting the plant. The review of this safety factor may require input from other safety factors (see Appendix I).	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 is necessary; — Updates of the final safety analysis report are necessary; — 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 Appendix I).

RELEVANT IAEA PUBLICATIONS

Evaluation of Seismic Safety for Existing Nuclear Installations, IAEA Safety Standards Series No. NS-G-2.13, IAEA, Vienna (2009).

External Events Excluding Earthquakes in the Design of Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-1.5, IAEA, Vienna (2004).

External Human Induced Events in Site Evaluation for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-3.1, IAEA, Vienna (2002).

Meteorological and Hydrological Hazards in Site Evaluations for Nuclear Installations, IAEA Safety Standards Series No. SSG-18, IAEA, Vienna (2011).

Protection against Internal Fires and Explosions in the Design of Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-1.7, IAEA, Vienna (2004).

Protection against Internal Hazards other than Fires and Explosions in the Design of Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-1.11, IAEA, Vienna (2004).

Safety of Nuclear Power Plants: Design, IAEA Safety Standards Series No. SSR-2/1, IAEA, Vienna (2012).

Seismic Hazards in Site Evaluation for Nuclear Installations, IAEA Safety Standards Series No. SSG-9, IAEA, Vienna (2010).

Site Evaluation for Nuclear Installations, IAEA Safety Standards Series No. NS-R-3, IAEA, Vienna (2003).

Volcanic Hazards in Site Evaluation for Nuclear Installations, IAEA Safety Standards Series No. SSG-21, IAEA, Vienna (2012).

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 an safety systems; • Failures of safety systems; • Unavailability of safety systems; • Trends in causes of failures (for example, operator errors, 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); • 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; • 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 Appendix I).	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, maintenance procedures; — Safety culture; — The final safety analysis report; — Strengths and weaknesses demonstrated by performance indicators; — Input data for the PSA. Results from the review of this safety factor may provide inputs to other safety factors (see Appendix I).

RELEVANT IAEA PUBLICATIONS

A System for the Feedback of Experience from Events in Nuclear Installations, IAEA Safety Standards Series No. NS-G-2.11, IAEA, Vienna (2006).

Maintenance, Surveillance and In-Service Inspection in Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-2.6, IAEA, Vienna (2002).

Operational Limits and Conditions and Operating Procedures for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-2.2, IAEA, Vienna (2000).

Operational Safety Performance Indicators for Nuclear Power Plants, IAEA-TECDOC-1141, IAEA, Vienna (2000).

Radiation Protection and Radioactive Waste Management in the Operation of Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-2.7, IAEA, Vienna (2002).

Safety Assessment for Facilities and Activities, IAEA Safety Standards Series No. GSR Part 4, IAEA, Vienna (2009).

Safety of Nuclear Power Plants: Commissioning and Operation, IAEA Safety Standards Series No. SSR-2/2, IAEA, Vienna (2011).

Safety of Nuclear Power Plants: Design, IAEA Safety Standards Series No. SSR-2/1, IAEA, Vienna (2012).

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; — 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; — Operating experience from similar plants in the State and in other States. Plant specific documents: The review of the use of experience from other plants and research finding should include, in particular, the following plant specific inputs: — Reports from the operating organization's routine assessment of operating experience at other plants; — Procedures and documentation governing the operating organization's process for the review of operating experience at other plants; — Assessments from the operating organization's review of emerging research findings; — Procedures and documentation governing the operating organization's routine process for the assessment of research findings; — 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 Appendix I).	IAEA Safety Standards Series No. NS-G-2.11 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 operating organization; — 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 Appendix I). This safety factor should be reviewed early in the PSR programme.

RELEVANT IAEA PUBLICATION

A System for the Feedback of Experience from Events in Nuclear Installations, IAEA Safety Standards Series No. NS-G-2.11, IAEA, Vienna (2006).

SAFETY FACTOR 10: ORGANIZATION, THE MANAGEMENT SYSTEM AND SAFETY CULTURE

Inputs	Outputs
Standards and requirements: — Current national and international standards and regulations; — Current national and international good practices. Plant specific documents: — The operating organization'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 organizational structure and safety related roles and responsibilities of individuals and groups; — Corrective action programme and processes for reporting; — Surveys of safety culture. Operating experience: — Operating experience with respect to organization and administration at plants in the State and in other States; — Internal audit and surveillance reports; — External audits (for example, reports from IAEA Operational Safety Review Team (OSART) missions) ; — Self-assessments; — Safety performance assessments; — Safety culture assessments. The review of this safety factor may require input from other safety factors (see Appendix I).	The review of organization, 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 operating organization; — Work processes (how work is specified, prepared, reviewed, performed, recorded, assessed and improved); — Control of documents, products and records; — The purchasing process; — Communication; — Organizational change management; — Commitment to safety; — Compliance with procedures; — The existence of a questioning attitude among personnel; — Whether the operating organization has a 'learning culture'; — Prioritization of safety issues; — Clarity of organizational roles and responsibilities; — Training on safety culture; — Regular safety culture assessments. Results from the review of this safety factor may provide inputs for other safety factors (see Appendix I).

RELEVANT IAEA/INSAG PUBLICATIONS

Application of the Management System for Facilities and Activities, IAEA Safety Standards Series No. GS-G-3.1, IAEA, Vienna (2006).

Deterministic Safety Analysis for Nuclear Power Plants, IAEA Safety Standards Series No. SSG-2, IAEA, Vienna (2009).

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Safety Assessment for Facilities and Activities, IAEA Safety Standards Series No. GSR Part 4, IAEA, Vienna (2009).

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The Management System for Facilities and Activities, IAEA Safety Standards Series No. GS-R-3, IAEA, Vienna (2006).

The Management System for Nuclear Installations, IAEA Safety Standards Series No. GS-G-3.5, IAEA, Vienna (2009).

The Operating Organization for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-2.4, IAEA, Vienna (2001).

SAFETY FACTOR 11: PROCEDURES

Inputs	Outputs
Standards and requirements: — Current national and international requirements for procedures; — 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); — Audits and self-assessments that question adherence to plant procedures. Operating experience: — Operating experience involving procedural issues at plants in the State and in other States; — Safety significant events involving procedural issues. The review of this safety factor may require input from other safety factors (see Appendix I).	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; — Safety culture. Results from the review of this safety factor may provide inputs for other safety factors (see Appendix I).

RELEVANT IAEA/INSAG PUBLICATIONS

Application of the Management System for Facilities and Activities, IAEA Safety Standards Series No. GS-G-3.1, IAEA, Vienna (2006).

Conduct of Operations at Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-2.14, IAEA, Vienna (2008).

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INTERNATIONAL NUCLEAR SAFETY ADVISORY GROUP, Maintaining Knowledge, Training and Infrastructure for Research and Development in Nuclear Safety, INSAG-16, IAEA, Vienna (2003).

Maintenance, Surveillance and In-Service Inspection in Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-2.6, IAEA, Vienna (2002).

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Severe Accident Management Programmes for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-2.15, IAEA, Vienna (2009).

The Management System for Facilities and Activities, IAEA Safety Standards Series No. GS-R-3, IAEA, Vienna (2006).

The Operating Organization for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-2.4, IAEA, Vienna (2001).

SAFETY FACTOR 12: HUMAN FACTORS

Inputs	Outputs
Standards and requirements: — Current national and international requirements; — 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; — Audits and self-assessments of hours of work and time records. Operating experience: — Operating experience involving human factors at plants in the State and in other States; — Safety significant events involving human factors. The review of this safety factor may require input from other safety factors (see Appendix I).	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; — Communications. Results from the review of this safety factor may provide inputs for other safety factors (see Appendix I).

RELEVANT IAEA/INSAG PUBLICATIONS

Application of the Management System for Facilities and Activities, IAEA Safety Standards Series No. GS-G-3.1, IAEA, Vienna (2006).

Human Reliability Analysis in Probabilistic Safety Assessment for Nuclear Power Plants, Safety Series No. 50-P-10, IAEA, Vienna (1996).

INTERNATIONAL NUCLEAR SAFETY ADVISORY GROUP, Safety Culture, INSAG-4, IAEA, Vienna (1991).

Recruitment, Qualification and Training of Personnel for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-2.8, IAEA, Vienna (2002).

The Management System for Facilities and Activities, IAEA Safety Standards Series No. GS-R-3, IAEA, Vienna (2006).

The Management System for Nuclear Installations, IAEA Safety Standards Series No. GS-G-3.5, IAEA, Vienna (2009).

The Operating Organization for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-2.4, IAEA, Vienna (2001).

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 operating organization; — Strategy, procedures and organization for emergencies; — Studies of the mitigation of consequences of accidents; — Procedures for the management of design extension conditions and accident management guidelines. Operating experience: — Records of emergency exercises held and lessons learned; — Lessons learned from exercises held in the State and in other States and from international exercises. The review of this safety factor may require input from other safety factors (see Appendix I), 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 organizations needs to be improved; — 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 Appendix I).

RELEVANT IAEA PUBLICATIONS

Arrangements for Preparedness for a Nuclear or Radiological Emergency, IAEA Safety Standards Series No. GS-G-2.1, IAEA, Vienna (2007).

Conduct of Operations at Nuclear Power Plants, Safety Standards Series No. NS-G-2.14, IAEA, Vienna (2008).

Developments in the Preparation of Operating Procedures for Emergency Conditions of Nuclear Power Plants, IAEA-TECDOC-341, IAEA, Vienna (1985).

Experience with Simulator Training for Emergency Conditions, IAEA-TECDOC-443, IAEA, Vienna (1987).

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Generic Assessment Procedures for Determining Protective Actions during a Reactor Accident, IAEA-TECDOC-955, IAEA, Vienna (1997).

Method for the Development of Emergency Response Preparedness for Nuclear or Radiological Accidents, IAEA-TECDOC-953, IAEA Vienna (1997).

Preparation, Conduct and Evaluation of Exercises to Test Preparedness for a Nuclear or Radiological Emergency, IAEA-EPR-EXERCISE, IAEA, Vienna (2005).

SAFETY FACTOR 14: RADIOLOGICAL IMPACT ON THE ENVIRONMENT

Inputs	Outputs
Standards and requirements: — Relevant national standards; — IAEA Safety Requirements and Safety Guides, including SSR-2/1, NS-G-1.13 and NS-G-3.2; — 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; — Published environmental data. The review of this safety factor may require input from other safety factors (see Appendix I), 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 Appendix I).

RELEVANT IAEA PUBLICATIONS

A System for the Feedback of Experience from Events in Nuclear Installations, IAEA Safety Standards Series No. NS-G-2.11, IAEA, Vienna (2006).

Dispersion of Radioactive Material in Air and Water and Consideration of Population Distribution in Site Evaluation for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-3.2, IAEA, Vienna (2002).

Radiation Protection and Radioactive Waste Management in the Operation of Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-2.7, IAEA, Vienna (2002).

Radiation Protection Aspects of Design for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-1.13, IAEA, Vienna (2005).

Safety of Nuclear Power Plants: Design, IAEA Safety Standards Series No. SSR-2/1, IAEA, Vienna (2012).

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