

IAEA Safety Standards

for protecting people and the environment

Periodic Safety Review for Nuclear Power Plants

Specific Safety Guide

No. SSG-25



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IAEA SAFETY STANDARDS

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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

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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.

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PERIODIC SAFETY
REVIEW FOR
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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

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2013

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Marketing and Sales Unit, Publishing Section
International Atomic Energy Agency
Vienna International Centre
PO Box 100
1400 Vienna, Austria
fax: +43 1 2600 29302
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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 measures¹ 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.

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

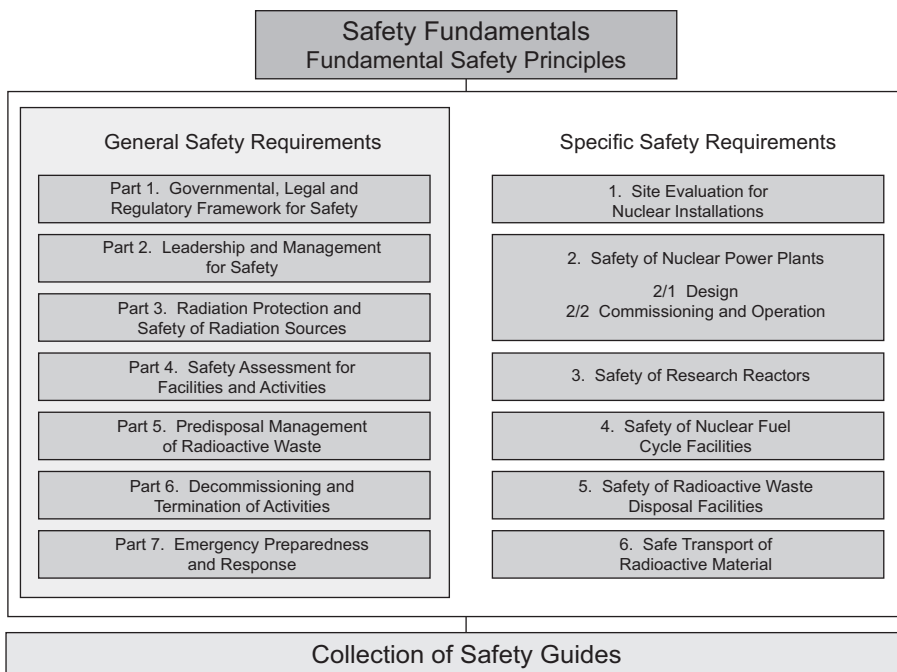


FIG. 1. The long term structure of the IAEA Safety Standards Series.

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

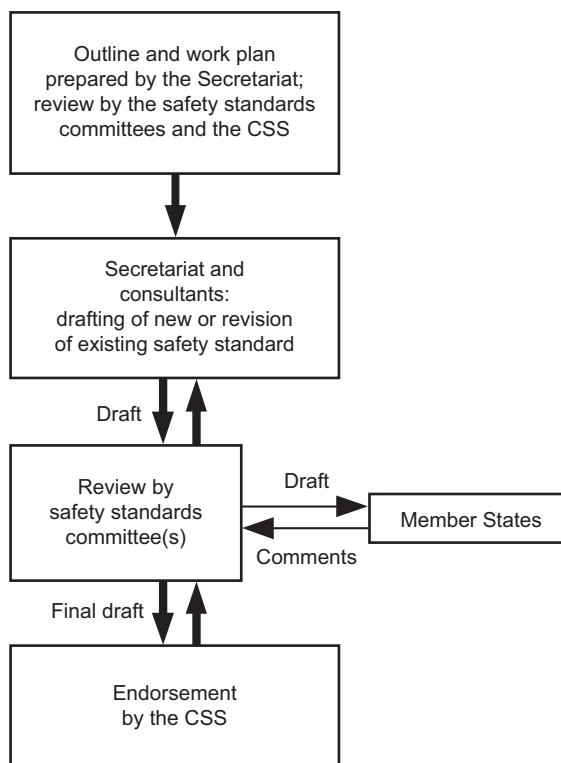


FIG. 2. The process for developing a new safety standard or revising an existing standard.

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.

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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.