

# IAEA SAFETY STANDARDS SERIES

## Periodic Safety Review of Nuclear Power Plants

### SAFETY GUIDE

No. NS-G-2.10



**IAEA**

International Atomic Energy Agency



# IAEA SAFETY RELATED PUBLICATIONS

## IAEA SAFETY STANDARDS

Under the terms of Article III of its Statute, the IAEA is authorized to establish standards of safety for protection against ionizing radiation and to provide for the application of these standards to peaceful nuclear activities.

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[www.iaea.org/ns/coordinet](http://www.iaea.org/ns/coordinet)

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# PERIODIC SAFETY REVIEW OF NUCLEAR POWER PLANTS

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# FOREWORD

**by Mohamed ElBaradei**  
**Director General**

One of the statutory functions of the IAEA is to establish or adopt standards of safety for the protection of health, life and property in the development and application of nuclear energy for peaceful purposes, and to provide for the application of these standards to its own operations as well as to assisted operations and, at the request of the parties, to operations under any bilateral or multilateral arrangement, or, at the request of a State, to any of that State's activities in the field of nuclear energy.

The following bodies oversee the development of safety standards: the Commission on Safety Standards (CSS); the Nuclear Safety Standards Committee (NUSSC); the Radiation Safety Standards Committee (RASSC); the Transport Safety Standards Committee (TRANSSC); and the Waste Safety Standards Committee (WASSC). Member States are widely represented on these committees.

In order to ensure the broadest international consensus, safety standards are also submitted to all Member States for comment before approval by the IAEA Board of Governors (for Safety Fundamentals and Safety Requirements) or, on behalf of the Director General, by the Publications Committee (for Safety Guides).

The IAEA's safety standards are not legally binding on Member States but may be adopted by them, at their own discretion, for use in national regulations in respect of their own activities. The standards are binding on the IAEA in relation to its own operations and on States in relation to operations assisted by the IAEA. Any State wishing to enter into an agreement with the IAEA for its assistance in connection with the siting, design, construction, commissioning, operation or decommissioning of a nuclear facility or any other activities will be required to follow those parts of the safety standards that pertain to the activities to be covered by the agreement. However, it should be recalled that the final decisions and legal responsibilities in any licensing procedures rest with the States.

Although the safety standards establish an essential basis for safety, the incorporation of more detailed requirements, in accordance with national practice, may also be necessary. Moreover, there will generally be special aspects that need to be assessed on a case by case basis.

The physical protection of fissile and radioactive materials and of nuclear power plants as a whole is mentioned where appropriate but is not treated in detail; obligations of States in this respect should be addressed on the basis of the relevant instruments and publications developed under the auspices of the IAEA. Non-radiological aspects of industrial safety and environmental protection are also not explicitly considered; it is recognized that States should fulfil their international undertakings and obligations in relation to these.

The requirements and recommendations set forth in the IAEA safety standards might not be fully satisfied by some facilities built to earlier standards. Decisions on the way in which the safety standards are applied to such facilities will be taken by individual States.

The attention of States is drawn to the fact that the safety standards of the IAEA, while not legally binding, are developed with the aim of ensuring that the peaceful uses of nuclear energy and of radioactive materials are undertaken in a manner that enables States to meet their obligations under generally accepted principles of international law and rules such as those relating to environmental protection. According to one such general principle, the territory of a State must not be used in such a way as to cause damage in another State. States thus have an obligation of diligence and standard of care.

Civil nuclear activities conducted within the jurisdiction of States are, as any other activities, subject to obligations to which States may subscribe under international conventions, in addition to generally accepted principles of international law. States are expected to adopt within their national legal systems such legislation (including regulations) and other standards and measures as may be necessary to fulfil all of their international obligations effectively.

#### EDITORIAL NOTE

*An appendix, when included, is considered to form an integral part of the standard and to have the same status as the main text. Annexes, footnotes and bibliographies, if included, are used to provide additional information or practical examples that might be helpful to the user.*

*The safety standards use the form 'shall' in making statements about requirements, responsibilities and obligations. Use of the form 'should' denotes recommendations of a desired option.*

*The English version of the text is the authoritative version.*

# CONTENTS

|    |                                                                                |    |
|----|--------------------------------------------------------------------------------|----|
| 1. | INTRODUCTION .....                                                             | 1  |
|    | Background (1.1–1.2) .....                                                     | 1  |
|    | Objective (1.3) .....                                                          | 1  |
|    | Scope (1.4–1.5) .....                                                          | 1  |
|    | Structure (1.6) .....                                                          | 2  |
| 2. | RATIONALE FOR AND OBJECTIVE<br>OF PERIODIC SAFETY REVIEW .....                 | 2  |
|    | Rationale for a PSR (2.1–2.7) .....                                            | 2  |
|    | Objective of a PSR (2.8) .....                                                 | 4  |
| 3. | REVIEW STRATEGY (3.1–3.9) .....                                                | 4  |
| 4. | SAFETY FACTORS IN A PERIODIC SAFETY REVIEW .....                               | 6  |
|    | Introduction (4.1–4.9) .....                                                   | 6  |
|    | Plant design (4.10–4.13) .....                                                 | 9  |
|    | Actual condition of systems,<br>structures and components (4.14–4.16) .....    | 10 |
|    | Equipment qualification (4.17–4.20) .....                                      | 11 |
|    | Ageing (4.21–4.25) .....                                                       | 12 |
|    | Deterministic safety analysis (4.26–4.28) .....                                | 13 |
|    | Probabilistic safety assessment (4.29–4.32) .....                              | 14 |
|    | Hazard analysis (4.33–4.35) .....                                              | 15 |
|    | Safety performance (4.36–4.38) .....                                           | 16 |
|    | Use of experience from other plants<br>and research findings (4.39–4.40) ..... | 17 |
|    | Organization and administration (4.41–4.42) .....                              | 18 |
|    | Procedures (4.43–4.44) .....                                                   | 19 |
|    | Human factors (4.45–4.46) .....                                                | 20 |
|    | Emergency planning (4.47–4.48) .....                                           | 20 |
|    | Radiological impact on the environment (4.49–4.50) .....                       | 21 |
|    | Global assessment (4.51–4.52) .....                                            | 22 |
| 5. | ROLES AND RESPONSIBILITIES (5.1–5.4) .....                                     | 22 |

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6. REVIEW PROCEDURE ..... 23

    Introduction (6.1–6.2) ..... 23

    Activities of the plant operating organization (6.3–6.17) ..... 29

    Activities of the regulatory body (6.18–6.24) ..... 32

7. BASIS FOR ACCEPTABILITY  
    OF CONTINUED PLANT OPERATION (7.1–7.3) ..... 33

8. POST-REVIEW ACTIVITIES (8.1–8.4) ..... 35

APPENDIX: ELEMENTS OF THE REVIEW ..... 36

REFERENCES ..... 43

GLOSSARY ..... 46

CONTRIBUTORS TO DRAFTING AND REVIEW ..... 49

BODIES FOR THE ENDORSEMENT OF SAFETY STANDARDS .. 50

# 1. INTRODUCTION

## BACKGROUND

1.1. This Safety Guide supplements the IAEA Safety Fundamentals publication The Safety of Nuclear Installations [1] and the Safety Requirements publication Safety of Nuclear Power Plants: Operation [2]. It supersedes the Safety Guide issued as Safety Series No. 50-SG-O12, Periodic Safety Review of Operational Nuclear Power Plants, in 1994.

1.2. Routine reviews of nuclear power plant operation (including 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 safety verification. In addition, some States have initiated systematic safety reassessment, termed periodic safety review (PSR), to assess the cumulative effects of plant ageing and plant modifications, operating experience, technical developments and siting aspects. The reviews include an assessment of plant design and operation against current safety standards and practices, and they have the objective of ensuring a high level of safety throughout the plant's operating lifetime. They are complementary to the routine and special safety reviews and do 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. The Safety Guide is directed at plant operating organizations and regulatory bodies.

## SCOPE

1.4. This Safety Guide deals with the PSR of an existing nuclear power plant. A PSR is a comprehensive safety review of all important aspects of safety, carried out at regular intervals, typically of ten years.

1.5. The review process described in this Safety Guide is valid for nuclear power plants of any age, but may have a wider applicability, for example, to research reactors and radioactive waste management facilities. A PSR is not

intended to deal with the decommissioning phase; however, documentation resulting from a PSR would be an important input for planning decommissioning.

## STRUCTURE

1.6. A rationale for and the objective of the PSRs of operational nuclear power plants are given in Section 2. Section 3 presents strategic considerations relating to the conduct of a PSR. Important aspects of the safety of an operational nuclear power plant that are addressed in a PSR are defined as safety factors and these are described in Section 4. The roles and responsibilities of the plant operating organization, the regulatory body and external consultants in the conduct of a PSR are defined in Section 5. Section 6 presents a recommended review procedure. Common aspects relating to the acceptability of continued plant operation are discussed in Section 7. Section 8 deals with post-review activities. Finally, the Appendix extends the description of safety factors given in Section 4 by listing for each safety factor specific topics or activities that should be included in the review.

## **2. RATIONALE FOR AND OBJECTIVE OF PERIODIC SAFETY REVIEW**

### RATIONALE FOR A PSR

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 practices, and in technology, resulting from new scientific and technical knowledge, better analytical methods and lessons learned from operating experience. These developments, however, do not mean that existing operational plants are unsafe; the overall safety record of nuclear power plants has been good [3].

2.2. Operational nuclear power plants in many States are subject to routine and special safety reviews. These safety reviews are generally not comprehensive and do not always take account of improvements in safety standards and operating practices, the cumulative effects of plant ageing,

modifications, the feedback of operating experience, and developments in science and technology. Consequently, the concept of PSR has been developed as a method that is complementary to the existing types of reviews.

2.3. PSRs are considered an effective way to obtain an overall view of actual plant safety, to determine reasonable and practical modifications that should be made in order to maintain a high level of safety and to improve the safety of older nuclear power plants to a level approaching that of modern plants. In this connection, it is useful to identify any lifetime limiting features of the plant in order to help evaluate whether a proposed modification is worthwhile.

2.4. On the basis of experience, the first PSR should be undertaken about ten years after the start of plant operation and subsequent PSRs every ten years until the end of operation. Within a period of ten years, the following developments would be expected: a likelihood of significant changes in safety standards, technology and underlying scientific knowledge and analytical techniques; a need for the evaluation of the cumulative effects of plant modifications and ageing; and a possibility of significant changes in the staffing and management structures of both the plant operating organization and the regulatory body.

2.5. If the period between PSRs is extended beyond about ten years, a substantial number of experienced staff in the operating organization and the regulatory body may have left these organizations, thus leading to a loss of the direct knowledge and experience gained during previous reviews and to a loss of continuity. Good documentation of the review process and its results will be of particular value in such circumstances. The documentation should be easily retrievable and clearly understandable.

2.6. A PSR is part of the regulatory system in many States. It is a key regulatory instrument for maintaining 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 a period established by safety evaluation. The PSR provides reassurance that there continues to be a valid licensing basis, with plant ageing, modifications made to the plant and current international safety standards taken into consideration.

2.7. It is recognized that some States prefer alternative arrangements to PSRs. A systematic safety assessment programme, dealing with specific safety issues, significant events and changes in safety standards and practices as they arise, is one example. This Safety Guide is not intended to discourage such alternative

arrangements. However, each alternative should demonstrate that it can satisfy the objective of a PSR as defined in para. 2.8.

## OBJECTIVE OF A PSR

2.8. The objective of a PSR is to determine by means of a comprehensive assessment of an existing nuclear power plant: the extent to which the plant conforms to current international safety standards and practices; the extent to which the licensing basis remains valid; the adequacy of the arrangements that are in place to maintain plant safety until the next PSR or the end of plant lifetime; and the safety improvements to be implemented to resolve the safety issues that have been identified. (An assessment against current safety standards does not imply that all current safety standards have to be met; see para. 7.1.)

## 3. REVIEW STRATEGY

3.1. The scope of a PSR includes all nuclear safety aspects of a nuclear power plant. For this purpose, a plant consists of all facilities and systems, structures and components (SSCs) on the site covered by the operating licence (including, for example, waste management facilities and on-site simulators) and their operation, together with the staff and its organization. The review also covers radiological protection, emergency planning and radiological impact on the environment — safety factors that are common to all units. Other safety factors (for example, the actual condition of SSCs, ageing and safety performance) are specific to each unit, and this should be taken into account in a PSR for a nuclear power plant with several units of the same design.

3.2. A comprehensive assessment of overall plant safety is a complex task. Experience shows that the task can be divided into a number of elements. These elements are termed safety factors in this Safety Guide. When the concept of safety factors is not used, the comprehensiveness of the review should be ensured by other means.

3.3. Each safety factor is reviewed using current methods and the findings are assessed against current safety standards and practices. Reasonable and practicable corrective actions and/or safety improvements are determined and

an implementation plan is agreed, with account taken of the interactions and overlaps between safety factors and hence of the effects of the corrective actions and/or safety improvements on all safety factors. The aim is to complete as many of the corrective actions and/or safety improvements as is reasonable within the time-frame of a PSR; however, it is recognized that it may take longer to implement some corrective actions and/or safety improvements.

3.4. A global assessment of any shortcomings that cannot be reasonably and practicably corrected is made, account being taken of all the corrective actions and/or safety improvements and the strengths of the nuclear power plant. The risks associated with the unresolved shortcomings should be assessed and an appropriate justification for continued operation should be provided.

3.5. The PSR should be conducted typically every ten years and its duration should not exceed three years. The starting point of a PSR is the time of the agreement between the operating organization and the regulatory body on the general scope and requirements for the PSR and its expected outcome. The end point of a PSR is the approval by the regulatory body of an integrated programme of corrective actions and/or safety improvements (containing a list of corrective actions and/or safety improvements and a schedule). (In general, adequate documentation of the design basis and of probabilistic safety assessment (PSA) is needed for a PSR. If such documentation is not readily available and a major effort would be necessary to obtain it, consideration should be given to obtaining it by means of projects separate from the PSR.)

3.6. PSA provides useful insights into the safety of a nuclear power plant and is consequently a useful contributor to a PSR. A PSA should be undertaken for every plant, should be kept up to date and should be utilized in subsequent PSRs.

3.7. The operating organization should have prime responsibility for performing the PSR. The requirements for the PSR should either be specified by the regulatory body after consultation with the operating organization or be developed by the operating organization and agreed upon with the regulatory body before the start of the review. These requirements should include clear statements of applicable safety goals, safety standards and the plant design basis. These constitute a reference level for the review and would normally remain unchanged for the duration of the PSR.

3.8. The results of relevant studies, and of routine and special safety reviews, should be utilized in the PSR to minimize any duplication of effort.

Appropriate references should be made and an explanation of the use of these references should be provided.

3.9. A PSR is a major and complex undertaking which necessitates effective project management and the provision of adequate resources. A survey of States indicates that 50–100 person-years are needed for performing a PSR (excluding the efforts made in implementing any corrective actions and/or safety improvements, in conducting a PSA or in recovering information on the design basis).

## 4. SAFETY FACTORS IN A PERIODIC SAFETY REVIEW

### INTRODUCTION

4.1. The 14 PSR safety factors have been selected on the basis of States' experience. These 14 safety factors are divided into five subject areas to facilitate the review. In addition, there is a global assessment to integrate the results of the review of individual safety factors.

#### *Plant*

- (1) Plant design,
- (2) Actual condition of SSCs,
- (3) Equipment qualification,
- (4) Ageing.

#### *Safety analysis*

- (5) Deterministic safety analysis,
- (6) Probabilistic safety analysis,
- (7) Hazard analysis.

#### *Performance and feedback of experience*

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

## *Management*

- (10) Organization and administration,
- (11) Procedures,
- (12) The human factor,
- (13) Emergency planning.

## *Environment*

- (14) Radiological impact on the environment.

## *Global assessment*

- Overall assessment of nuclear power plant safety, with account taken of the results of the review of individual safety factors, including agreed corrective actions and/or safety improvements.

4.2. The 14 PSR safety factors selected apply to all the facilities on the plant site, including radioactive waste management facilities (see para. 3.1), and are considered sufficient for a comprehensive review of safety. However, the set of safety factors may vary according to the specific needs of the State and the particular nuclear power plant under consideration, and they should be agreed upon before the PSR is initiated. In this connection, PSR experience from nuclear power plants of the same design should be taken into account in the choice of safety factors.

4.3. All safety factors are important to operational safety, including accident prevention and mitigation of the consequences of accidents. The safety factors are subdivided into groups to facilitate the review; however, the order and numbering of the safety factors do not indicate an order of importance.

4.4. For the purpose of a PSR, the subject area safety analysis is subdivided into three safety factors — deterministic safety analysis, PSA and hazard analysis — to facilitate the review according to current practices. Each of these safety factors requires specific tools and expertise. Quality assurance (QA) and safety culture are not considered to be separate safety factors because they should be an integral part of every activity affecting safety. QA is assessed in its own right as an aspect of organization and administration. As regards safety culture, in reviewing each safety factor, consideration should be given to whether there is evidence of an appropriate safety culture in plant operations. Similarly, radiological protection is not regarded as a separate safety factor

since it is related to most of the other safety factors. The arrangements for radiological protection and their effectiveness should generally be reviewed as specific aspects of the safety factors: plant design, actual condition of SSCs, safety performance and procedures of the nuclear power plant. However, it may be desirable in some States to review radiological protection as a separate safety factor.

4.5. A review of the physical protection of nuclear power plants is typically not included in the PSR because of the sensitivity of this subject and the confidentiality aspect. The security arrangements should prevent unauthorized actions that could jeopardize safety and their effectiveness should be periodically reviewed.

4.6. Although the PSR determines the divergences of the plant from current safety standards and practices for individual safety factors, the level of plant safety is determined by a global assessment reflecting the combined effects of all safety factors. Although shortcomings may be individually acceptable, their combined effect should also be reviewed for acceptability, by means of PSA where appropriate. It is also possible that a weakness in one safety factor can be compensated for by a strength in another safety factor. For example, it may be acceptable on a temporary 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) until an appropriate modification to the design or equipment can be made. In such a case, the acceptability of the interim arrangements should be confirmed by the safety analysis.

4.7. The review should determine the status of each safety factor at the time of the PSR and whether the established operating regime will in future be capable of identifying and preventing or mitigating potential failures before they could cause a radiological incident. Age related degradation mechanisms that could lead to failures of key SSCs of the nuclear power plant and that could potentially limit the plant operating lifetime should be identified to the extent possible.

4.8. The level of effort necessary in the review of a safety factor is dependent on the availability and retrievability of relevant information.

4.9. The 14 PSR safety factors and the global assessment are defined and explained in the following subsections. The objective of the review of each

safety factor is given, as well as a description of the safety factor, its desired status and those aspects of the safety factor that should be reviewed. The Appendix elaborates on the description of safety factors by suggesting further elements that should be included in the review.

## PLANT DESIGN

### Objective

4.10. The objective of the review of the design of the nuclear power plant is to determine the adequacy of the design and its documentation in an assessment against current international standards and practices. (The term ‘nuclear power plant’ includes all SSCs on the site, as stated in para. 3.1.)

### Description

4.11. Plant SSCs important to safety should have appropriate characteristics and should be combined and laid out in such a way as to meet the requirements for plant safety and performance, including the prevention and mitigation of events that could jeopardize safety. The safety requirements for design are given in Ref. [4]. Adequate design information, including information on the design basis, should be available to provide for the safe operation and maintenance of the plant and to facilitate plant modifications.

4.12. The review of the plant design should establish a comprehensive list of SSCs important to safety (the current version of the safety analysis report may be helpful in performing this activity). It should identify the differences in plant design in an assessment against current safety standards (including relevant design codes) and determine their safety significance (strengths or weaknesses) in relation to the application of defence in depth. The review of the plant design is usually subdivided into review topics by systems, such as reactor core, reactor coolant system, containment system, instrumentation and control systems, electrical power systems and water supply systems.

4.13. For some older nuclear power plants, documentation relating to the safety of the design basis will not have been supplied in full to the operator at the commissioning stage. A PSR should ensure that all significant documentation relating to the original design basis has been obtained, securely stored and updated to reflect all the modifications made to the plant and procedures since its commissioning. This is of particular importance for plants that have