IAEA-TECDOC-1643

Periodic Safety Review of Nuclear Power Plants: Experience of Member States

IAEA

International Atomic Energy Agency

PERIODIC SAFETY REVIEW
OF NUCLEAR POWER PLANTS:
EXPERIENCE OF MEMBER STATES

The following States are Members of the International Atomic Energy Agency:

AFGHANISTAN
ALBANIA
ALGERIA
ANGOLA
ARGENTINA
ARMENIA
AUSTRALIA
AUSTRIA
AZERBAIJAN
BAHRAIN
BANGLADESH
BELARUS
BELGIUM
BELIZE
BENIN
BOLIVIA
BOSNIA AND HERZEGOVINA
BOTSWANA
BRAZIL
BULGARIA
BURKINA FASO
BURUNDI
CAMBODIA
CAMEROON
CANADA
CENTRAL AFRICAN REPUBLIC
CHAD
CHILE
CHINA
COLOMBIA
CONGO
COSTA RICA
CÔTE D'IVOIRE
CROATIA
CUBA
CYPRUS
CZECH REPUBLIC
DEMOCRATIC REPUBLIC OF THE CONGO
DENMARK
DOMINICAN REPUBLIC
ECUADOR
EGYPT
EL SALVADOR
ERITREA
ESTONIA
ETHIOPIA
FINLAND
FRANCE
GABON
GEORGIA
GERMANY
GHANA
GREECE
GUATEMALA
HAITI
HOLY SEE
HONDURAS
HUNGARY
ICELAND
INDIA
INDONESIA
IRAN, ISLAMIC REPUBLIC OF
IRAQ
IRELAND
ISRAEL
ITALY
JAMAICA
JAPAN
JORDAN
KAZAKHSTAN
KENYA
KOREA, REPUBLIC OF
KUWAIT
KYRGYZSTAN
LATVIA
LEBANON
LESOTHO
LIBERIA
LIBYAN ARAB JAMAHIRIYA
LIECHTENSTEIN
LITHUANIA
LUXEMBOURG
MADAGASCAR
MALAWI
MALAYSIA
MALI
MALTA
MARSHALL ISLANDS
MAURITANIA
MAURITIUS
MEXICO
MONACO
MONGOLIA
MONTENEGRO
MOROCCO
MOZAMBIQUE
MYANMAR
NAMIBIA
NEPAL
NETHERLANDS
NEW ZEALAND
NICARAGUA
NIGER
NIGERIA
NORWAY
OMAN
PAKISTAN
PALAU
PANAMA
PARAGUAY
PERU
PHILIPPINES
POLAND
PORTUGAL
QATAR
REPUBLIC OF MOLDOVA
ROMANIA
RUSSIAN FEDERATION
SAUDI ARABIA
SENEGAL
SERBIA
SEYCHELLES
SIERRA LEONE
SINGAPORE
SLOVAKIA
SLOVENIA
SOUTH AFRICA
SPAIN
SRI LANKA
SUDAN
SWEDEN
SWITZERLAND
SYRIAN ARAB REPUBLIC
TAJIKISTAN
THAILAND
THE FORMER YUGOSLAV REPUBLIC OF MACEDONIA
TUNISIA
TURKEY
UGANDA
UKRAINE
UNITED ARAB EMIRATES
UNITED KINGDOM OF GREAT BRITAIN AND NORTHERN IRELAND
UNITED REPUBLIC OF TANZANIA
UNITED STATES OF AMERICA
URUGUAY
UZBEKISTAN
VENEZUELA
VIETNAM
YEMEN
ZAMBIA
ZIMBABWE

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-TECDOC-1643

PERIODIC SAFETY REVIEW OF NUCLEAR POWER PLANTS: EXPERIENCE OF MEMBER STATES

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2010

Sales and Promotion, Publishing Section
International Atomic Energy Agency
Vienna International Centre
PO Box 100
1400 Vienna, Austria
fax: +43 1 2600 29302
tel.: +43 1 2600 22417
email: sales.publications@iaea.org
http://www.iaea.org/books

For further information on this publication, please contact:

Safety Assessment Section
International Atomic Energy Agency
Vienna International Centre
PO Box 100
1400 Vienna, Austria
email: Official.Mail@iaea.org

PERIODIC SAFETY REVIEW OF NUCLEAR POWER PLANTS:
EXPERIENCE OF MEMBER STATES
IAEA, VIENNA, 2010
IAEA-TECDOC-1643
ISBN 978-92-0-100710-0
ISSN 1011-4289

Printed by the IAEA in Austria
April 2010

FOREWORD

Routine reviews of nuclear power plant operation (including modifications to hardware and procedures, 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, many Member States of the IAEA have initiated systematic safety reassessments, termed periodic safety reviews, of nuclear power plants, 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.

Periodic safety reviews of nuclear power plants are considered an effective way to obtain an overall view of actual plant safety, and to determine reasonable and practical modifications that should be made in order to maintain a high level of safety. They can be used as a means of identifying time limiting features of the plant in order to determine nuclear power plant operation beyond the designed lifetime. The periodic safety review process can be used to support the decision making process for long term operation or licence renewal.

Since 1994, the use of periodic safety reviews by Member States has substantially broadened and confirmed its benefits. Periodic safety review results have, for example, been used by some Member States to help provide a basis for continued operation beyond the current licence term, to communicate more effectively with stakeholders regarding nuclear power plant safety, and to help identify changes to plant operation that enhance safety.

This IAEA-TECDOC is intended to assist Member States in the implementation of a periodic safety review. This publication complements the recommendations provided in the IAEA Safety Standards Series publication on Periodic Safety Review of Nuclear Power Plants, NS-G-2.10, and discusses further alternative approaches. Following the publication of this Safety Guide the IAEA organized technical and consultants meetings on experience of Member States in implementing periodic safety reviews at nuclear power plants, in order to give a platform to Member States for exchanging their experiences. This IAEA-TECDOC summarizes these Member States’ experiences and practices. This publication can also be used to update IAEA Standards Series No. NS-G-2.10.

The IAEA wishes to thank all the participants for their contributions to this publication, in particular the contributions of P.I. Banks (UK), H.P. Berg (Germany), T. Katona (Hungary) and V. Kotyza (Czech Republic). The IAEA officer responsible for this publication was C. Toth of the Division of Nuclear Installation Safety.

EDITORIAL NOTE

CONTENTS

1. INTRODUCTION

1.1 BACKGROUND

Fundamental Safety Principles [1], states that safety has to be assessed for all facilities and activities, consistent with a graded approach and that the process of safety assessment is repeated, in whole or in part, to take into account changed circumstances such as the application of new standards or scientific and technological developments, operating experience feedback, modifications, and the effects of ageing.

Operational nuclear power plants are generally subject to routine reviews of plant operation and special safety reviews following operational events. For many Member States, these routine and reactive safety reviews are generally focused reviews and do not consider changes in safety standards and operating practices, the cumulative effects of plant ageing, plant modifications, feedback of operating experience and developments in science and technology. In order to address these potential impacts on plant safety, many Member States periodically conduct a comprehensive, integrated safety review, commonly referred to as a periodic safety review (PSR). PSR is performed for nuclear power plants in operation, not for nuclear power plants in the decommissioning phase.

The scope of these reviews differs from Member State to Member State and in some Member States the name PSR is not used because the integral and comprehensive character of such a review has been considered more important than its periodicity.

To facilitate the implementation of PSR by Member States, the IAEA issued in 1994 a Safety Guide on Periodic Safety Reviews of Operational Nuclear Power Plants (50-SG-O12) [2]. Since 1994, the use of PSR by Member States has substantially broadened and confirmed its benefits. PSR results have, for example, been used by some Member States to help provide a basis for continued operation beyond the current licence term, to communicate more effectively with stakeholders regarding nuclear power plant safety, and to help identify changes to plant operation that enhance safety. Based on the Member State experiences in performing PSRs, a revised Safety Guide was issued in 2003 [3]. The IAEA Safety Guide on PSRs describes only one possible approach to perform a PSR in detail.

The typical interval between PSRs in Member States is 10 years. During this period, significant changes may occur, for example the evolution of national regulations, worldwide safety methodologies and analysis tools. This period is also long enough for the identification of trends and the drawing of conclusions based on operational and safety records. As the originally intended and planned lifetime of nuclear power plant units was typically 30–40 years, this means that the first PSR period will cover the early period of operation, when the unit is relatively modern. The second PSR will cover the middle-aged period of the unit's operation; and the third PSR during the later life period will possibly consider safety enhancements and the consideration of issues related to long-term operation such as ageing. However, it is important to note that the PSR activity is both additional and complementary to the normal regulatory and oversight processes and the licensee programmes, policies and procedures which govern day-to-day/year-to-year operation of a nuclear power plant.

To assist Member States in performing PSRs, the IAEA has prepared this IAEA-TECDOC, which documents the experiences of Member States in the implementation of PSRs.

1.2 OBJECTIVE

The objective of this report is to assist Member States in the implementation of PSR. The information in this IAEA-TECDOC reflects the experience of Member States in performing PSRs, complements the guidance provided on PSR in Ref. [3], and discusses alternative approaches for completing a PSR.

1.3 STRUCTURE

There are five sections in the main report: Section 2 presents the legal framework of PSRs. Section 3 discusses the methodology and guidelines for performing PSRs. Section 4 discusses the principal stages of the PSR, including details of the safety factor approach for carrying out a PSR. The benefits and required resources of a PSR are summarized in Section 5. The Appendix contains a summary of Member States' practices in carrying out PSRs to date or, in cases where PSRs have still to be performed, it reflects Member States' current intentions. Annex I presents an example of the mapping of an alternative approach to structuring PSR in order to demonstrate comprehensiveness and consistency with the safety factor approach in Section 4. Annex II shows an example of a flow chart for the preparation of a PSR. Annex III discusses various approaches to performing a PSR, Annex IV describes the US alternative to a PSR. Annex V shows as a practical example how the human factors safety factor can be addressed in a PSR scope and methodology document.

1.4 BASIC PRINCIPLES OF PSR

From the advice provided in Refs [2] and [3] and subsequent experience of Member States in conducting PSRs, the following general principles are now accepted:

Role of PSR — PSR is a comprehensive, integrated review that considers long term operational and safety performance trends. PSRs are complementary to the ongoing regulatory oversight and inspections processes and the licensee's ongoing programmes, procedures and processes to safely operate the plant. The corrective action plan to resolve findings arising from the review is an integral part of the PSR.

Scope — the scope of the review should be comprehensive, covering all relevant safety issues (based, for example on safety factors as given in Ref. [3] and taking into account safety classification of equipment) and should be agreed between the licensee and regulator prior to commencing the review. The scope and results of the first PSR may be different to that for the following ones.

Periodicity — PSRs are generally conducted approximately every 10 years.

Management — the nuclear power plant licensee should manage and provide technical leadership for the PSR and may use support from external consultants, where appropriate.

Regulatory assessment — regulator approves the requirements for the PSR, follows the review process, assesses the results and performance of corrective actions.

The PSR reports, especially the summary report, would normally identify both strengths and areas for improvement, and present a balanced assessment of nuclear power plant safety.

1.5 SCOPE AND CHARACTER OF PSR

The general scope and principles of a PSR as described in Section 1.4 remain valid for all PSRs carried out during the lifetime of a nuclear power plant. However, it was recognized that there may be a substantial difference between the results of the first and the following PSRs at the nuclear power plant or when the PSR is used for long term operation of a nuclear power plant. A character of findings and subsequent corrective actions reflect real status of the plant, taking into account previous maintenance and modernization, application of actual safety standards and cumulative impacts of plant ageing.

First PSRs for old nuclear power plants:

In the case of a first PSR for a nuclear power plant built to earlier standards, experience has shown that for a large number of nuclear power plants, with poor or limited documentation, the design bases had to be recovered, the design documentation updated in accordance with actual configuration and a proper safety justification (for example by renewal of the obsolete or incomplete FSAR) had to be provided. Moreover, the initial PSRs for older nuclear power plants recognized mainly technical obsolescence of the plant leading to safety upgrading of plant systems, structures and components (SSCs).

For some plants, with modern configuration management and safety analysis, the first PSR has been used to confirm the design basis and safety and hazard analysis as documented. The scope of this task is much less onerous compared to the first PSR for many older plants.

The second and subsequent PSRs:

The second and subsequent PSRs take into consideration the results of the first PSR and the implementation of the corrective actions previously identified. These PSRs must still evaluate the design, in particular relevant modifications implemented since the last PSR.

For plants performing their first PSR in the 1990s, their second PSR results are often more focused on ageing of the plant and safety management aspects.

In summary, the first and subsequent PSRs were used either to demonstrate the required safety level and safety margin until the next PSR or for the extension of the operating licence within the operational lifetime. Furthermore, the PSR is now being used by some Member States to support the decision on the extension of the operational lifetime of the nuclear power plant.

2. THE PERIODIC SAFETY REVIEW (PSR) WITHIN THE REGULATORY FRAMEWORK

2.1 REGULATORY FRAMEWORK

As previously mentioned, Ref. [1], states that safety has to be assessed for all facilities and activities, consistent with a graded approach and that the process of safety assessment is repeated, in whole or in part, to take into account changed circumstances such as the application of new standards or scientific and technological developments, operating experience feedback, modifications, and the effects of ageing.

In addition, Article 14 of The International Convention on Nuclear Safety (1994) covers 'Assessment of Verification and Safety'. This requires that each contracting party takes the appropriate steps to ensure that:

"…comprehensive and systematic safety assessments are carried out during construction and commissioning of a nuclear installation and throughout its life. Such assessments shall be well documented, subsequently updated in the light of operating experience and new safety information, and reviewed under the authority of the regulatory body".

Member States generally comply with the Fundamental Safety Principles [1] and the Articles of the Convention on Nuclear Safety through adoption and implementation of national regulatory requirements and guidelines. Each Member State retains the flexibility to meet the intent of these requirements in a manner that is consistent with its regulatory and legal framework.

The IAEA Safety Guide No NS-G-2.10 [3] for the performance of PSRs can facilitate Member States' obligations in complying with these fundamentals and requirements. However, PSRs are one approach to complying with these fundamentals and requirements and it is recognised that some Member States prefer alternative arrangements to PSRs. Examples of alternative arrangements include systematic assessment programmes (such as control of effectiveness of maintenance programmes) and programmes dealing with specific safety issues, significant events and changes in safety standards and practices as they arise.

2.2 ROLE OF PSR IN THE REGULATORY PROCESS

Nuclear power plants are subject to a process of continuous safety reviews throughout their operating lives. This process occurs at different time intervals and includes, for example, the following:

- day to day operation including testing of safety related components;
- modifications of plant design, procedures and organizations, e.g. during refuelling and maintenance;
- Review and renewal of the operating licence.

Special safety reviews are also conducted following events of safety significance. These reviews are usually self initiated by the licensee or may be requested by the authorities. All significant/unusual events are analysed by the licensees and reviewed by the regulatory organizations to ensure that causes are correctly identified, corrective actions taken and lessons learned disseminated.

The role of a PSR, performed approximately every 10 years, is both additional and complementary to the above processes. Therefore, PSR takes note of results of previous or ongoing review activities, including routine regulatory or nuclear power plant assessments and reviews.

PSR is a comprehensive, integrated assessment which provides a complete picture of the plant safety status at a fixed point in time. The PSR approach allows trends analysis, e.g. resulting from inspections, over the operating period since the last PSR. It also provides a basis for the evaluation of the expected safety level of the plant up to the next PSR. In this context, PSR may be used as an input for licensing renewal and long term operation of nuclear power plants (see Section 3.3).

General guidance for performing a PSR is given in Ref. [3]. However, the precise approach taken by each member state depends on the national legal context and the defined role of PSR in their respective regulatory processes. The Appendix contains summarized information regarding the various regulatory approaches taken by Member States.

In most cases guidelines are either provided by the regulator or provided by the licensee and discussed/agreed with the regulator prior to commencing the PSR. Moreover, the Western European Nuclear Regulators' Association established, within their process to harmonize nuclear safety, safety issues with a set of safety reference levels. One issue is a periodic safety review [4], taking into account the general recommendations of Ref. [3].

2.3 NATIONAL EXPERIENCES IN PERFORMING PSR OR ALTERNATIVE PROCESSES

The IAEA Safety Guide on PSR [3] describes one possible approach to perform a PSR in detail. This Safety Guide was broadly accepted as guidance on PSR, although some Member States have adopted modifications to the process of the review to meet their needs. The Appendix contains a summary of the experiences of Member States in performing PSRs.

Due to duration and efforts needed for the performance of a PSR, experience has shown that it would be useful to align the PSR procedures with ongoing review activities, to avoid unnecessary overlaps and duplication of efforts.

Annex III contains examples of different approaches to perform a PSR not based on the safety factor approach. Annex IV shows an example of an alternative process to PSR to assess the safety level of a plant.

3. METHODOLOGY AND GUIDELINES USED FOR PERFORMING PSR

3.1 SCOPE OF PSR

The scope of a PSR should be comprehensive, covering all nuclear safety aspects of a nuclear power plant (based, for example on safety factors as given in Ref. [3] and summarized in Section 4 of this publication), and taking into account equipment safety classification. 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 their operation, together with the staff and its organization.

Prior to commencing the review activities some Member States have prepared a PSR scope and methodology document which defines, for example, the following:

- The relevant current standards against which the plant/review area is to be compared, e.g. IAEA Safety Guides, safety assessment criteria, thermal hydraulic analysis codes, SSC design codes, hazard magnitude derivation data (seismic, meteorological, air traffic statistics), site and population characteristics and other relevant codes for assessing of plant design, actual condition of plant systems, plant operation, management and other safety factors (areas).
- Review methodology for each safety factor/review area
- The boundaries/interfaces for each safety factor or review area necessary to ensure comprehensive review coverage.
- The requirement to consider all known relevant ageing/degradation mechanisms necessary to demonstrate safe operation during the period up to the next PSR.
- Risk informed safety goals
- Radiological safety goals
- Project organization requirements (including communication).

When completed and agreed by all stakeholders within the operating organization the scope document is usually submitted for regulatory consideration and comment/feedback before commencing the review phase. It should be noted that in some Member States it is the practice for the regulator to prepare the scope document.

It should be noted that while some safety factors are common to more than one unit on a multi-unit site (such as emergency planning, radiological protection and radiological impact on the environment), others are unit-specific such as the actual condition of SSCs, ageing and safety performance.

3.2 METHODS USED FOR PERFORMING PSR

3.2.1 Technical Aspects of Review

There are essentially three complementary types of methodology for assessing power plant safety, namely engineering, deterministic and probabilistic. When carrying out a PSR it is advised that the respective approaches are utilized as follows (see Ref. [5]):

(a) Engineering assessment could be applicable for safety issues or safety factors, which compares and assesses the actual status of the plant with the current safety requirements, design codes and standards. This review should be performed on the basis of the existing plant documentation corresponding to the current status of systems, structures and components (SSC) important to safety. This review should cover the range of operating duties/loads, within normal operation, design basis accidents and beyond design basis accidents. Due consideration should be given to the results of any relevant operating experience

(b) Deterministic safety analysis performed for normal operation, transients and accident conditions should demonstrate whether the plant design is capable of meeting the prescribed regulatory limits (for the limiting safety parameters and finally for radiation doses and radioactive releases resulting from postulated accidents), taking into account the actual status of the plant.

(c) Probabilistic safety analysis (PSA) including human reliability assessment (HRA) involves the use of a whole plant model combined with modelling of the more significant actions required of the operator. This provides qualitative and quantitative insights into the safety of the nuclear power plant and consequently is useful in ranking the PSR findings in terms of their relative safety significance. Care should be taken that uncertainty values are considered when using the results from the PSA since absolute numerical values are subject to uncertainty.

The combination of the analyses cited above confirms the level of defence in depth; see for example Refs [6] and [7].

3.2.2 Review of Safety Management, Organizational and Safety Cultural Aspects

Guidance for reviewing these aspects is more limited than for the technical aspects. However, from the experiences of some member states it is recommended that the principles of INSAG-4 [8], INSAG-13 [9], INSAG-14 [10] and INSAG-15 [11] may be used to assess performance; safety culture in maintenance is addressed in Ref. [12].

Reference to the outcome of independent audits or IAEA peer review missions (e.g. OSART, IRRS, SCART, etc.) may also be used to support these areas of the PSR.

3.3 ROLE OF PSR IN LONG TERM OPERATION

Some Member States use the PSR results as a regulatory basis for long term operation [13]. If so, then the PSR may include the following additional features:

- The broader focus of the long term operations (LTO) process including, for example, reviews of time limiting ageing analysis (TLAA)
- The systematic approach identifying SSCs within the scope of LTO
- The engineering evaluation using defined acceptance criteria
- The re-evaluation of the radiological impact on the environment

An assessment of the feasibility of long term operation can also be used by licensees to consider the associated investment costs in terms of both safety-related and conventional plant replacement/refurbishment against the expected benefits in terms of continued operation beyond the original design life of the plant.

3.4 SAFETY FACTOR APPROACH

A comprehensive assessment of overall plant safety is a complex task. Experience has shown that one approach is to divide the review into a number of ‘safety factors’ as detailed in Section 4 of this report and Ref. [3]. The PSR strategy/structure may however vary according to the specific requirements of the individual licensee/utility, e.g. the desire to align the PSR structure with the final safety analysis report (FSAR) structure. In this case, comprehensive coverage can be ensured by mapping the IAEA safety factors to the proposed alternative structure of the PSR. An example of such a mapping is shown in Annex I.

3.5 REQUIREMENTS FOR PSR REPORT

The PSR reports, especially the summary report, would normally identify both strengths and areas for improvement to present a balanced assessment of nuclear power plant safety. In general the outcome of a PSR may be documented in a series of reports as follows:

a.) A set of 14 individual safety factor assessment reports

These are the building blocks of the entire review. Within each of these reports the findings specific to the safety factor concerned are documented and ranked according to their safety significance. In some Member States it is the practice to group some of the safety factors within a single report.

The following is a **suggested** example of the high level format of a typical safety factor report:

•*Title of safety factor*

•*Introduction*

•*Scope of Review*

•*Review Criteria (Reference standards, Safety Assessment criteria etc.)*

•*Review methodology*

•*Review performance since previous PSR*

•*Compare the current standards with those prevalent at the time of the previous PSR to identify /assess the significance of any changes*

•*Review results/identification of findings*

•*Evaluation of the safety relevance of the findings and their ranking*

•*Extrapolation for the next ten years period of time*

•*Conclusions*

•*References*

•*Appendices*

b.) A global assessment report

This report summarizes the outcome of the consolidation of the results/findings from each of the 14 safety factor assessment reports (the global assessment process is described in section 4.6). It also identifies coherent findings which lead logically to the definition of appropriate corrective actions which will improve plant safety and therefore improve compliance with safety standards. For more detail refer to section 4.6.

c.) An executive summary report.

This is a brief overview (30-40 pages) of the outcome of the PSR to inform key stakeholders of the most safety significant findings including the prospects for safe operation for the period at least until the next PSR

d.) Integrated implementation plan

The integrated implementation plan incorporates the corrective actions which resulted from findings from both the regulator and the licensee. The corrective actions are prioritized on the basis of safety significance and the plan identifies the timeline for completing them. For more detail refer to section 4.7.

4. ACTIVITIES FOR THE PREPARATION OF THE PSR

There are five principal activities in performing a PSR:

- Preparation
- Review of safety factors
- Global Assessment
- Regulator's Assessment
- Programme for Implementation of Corrective Actions including updating of Plant Documents

The practices of some Member States associated with each of the above activities are described below.

A flow chart describing the process of the activities of the licensee for an integrated safety review from defining the scope and methods for the review to the preparation of the final report, to be submitted to the regulator, is shown in Annex II.

4.1 PREPARATION

The preparation stage is very important in order to avoid difficulties during the performance of the review. Therefore, the arrangements, infrastructure and clear definition of roles and responsibilities are essential pre-requisites to an efficient and effective PSR. Many member states have implemented at the onset of the review a project management system in order to achieve the expected outcome within the agreed time-scale and budget.

To ensure the appropriate quality for the PSR documentation, a quality management plan is prepared which, for example, defines the roles and responsibilities of those involved in the project and the requirements for the preparation and verification of the PSR documentation.

In addition to the Scope and Methodology document, the development of project procedures covering topics such as conduct of plant survey/walkdown, a conduct of global assessment, a process for addressing identified safety issues, a process for responding to issues raised as a result of the regulator's assessment, a process for prioritizing the identified issues, and a process for the implementation of a corrective action plan are good practices. Documented Quality Assurance requirements, including roles, responsibilities, key interfaces, and documentation and verification requirements are also recommended.

A PSR is a major task requiring the coordination of a large number of stakeholders and the expenditure of major resources. As such, a project management approach to the review is recommended by many Member States. This would involve, for example, the following:

- The appointment of an experienced, dedicated project leader and project management team with adequate resources allocated to perform the review.
- A fully resourced project plan with milestones and identified deliverables. For many Member States the scope and major milestones and deliverables for the PSR are agreed between the operator and the regulator prior to commencing the review phase. The agreed programme includes timelines for performing the reviews and adequate time for the regulator's assessment.
- Development of an associated training plan for contributors and stakeholders of the project
- A defined PSR documentation structure. This will be specific to each operator but care must be taken to ensure that the overall PSR document structure covers all the safety issues identified for the review. Justification should be provided for any nuclear safety issues that are excluded from the review.
- Development of a project communication plan
- Pre-job briefings and post-job debriefings (lessons learned) at each phase of the project.

In parallel with licensee's preparation for the PSR, the regulatory body designates a PSR project manager to co-ordinate all the regulatory body's PSR activities. To ensure that regulatory overview of the PSR is carried out efficiently and effectively, a PSR project manager would be the single point of contact for communication with the licensee.

4.2 ROLE OF DIFFERENT ORGANIZATIONS

The management and technical leadership of the PSR should come from within the operator's organization. All work prepared in support of the PSR should be independently reviewed by or on behalf the PSR project management team to ensure that it meets the overall PSR objectives, is of the required quality and that all interacting safety issues are appropriately and consistently addressed. Where a PSR topic involves novel analysis techniques or the consideration of new issues, then consideration should be given to obtaining an independent review (e.g. IAEA support, WANO Technical Support Mission). In the case of safety management and safety culture some form of independent evaluation (e.g. external audit or review) is desirable.

In many Member States the safety factor reviews are carried out by contractors. It is important to ensure that the contractors understand the requirements for a PSR and how their work fits into the overall PSR effort. It is the responsibility of the licensee to review the work of contractors to verify that it meets the licensee's expectations for comprehensiveness and completeness. In particular, the licensee needs to understand and agree to the gaps identified by the contractors. It is also important for the licensee to ensure that the information resulting from these reviews is transferred to the licensee in such a manner that the information is easily retrievable and understood.

The principal roles and responsibilities for conducting a PSR are as follows:

Licence Holder **–** Ultimate responsibility for the safety of an nuclear power plant rests with the licensee. It is therefore essential that, whilst some aspects of the review may be contracted out, the management and technical leadership of the PSR should come from within the operator's organization.

PSR Project Leadership **–** The project leader will be responsible for ensuring delivery of the PSR to the appropriate quality, agreed timescale and budget. As such, the Project manager should be of appropriate authority within the organization and preferably have past experience in PSR and a broad based technical knowledge. Organizational arrangements may differ depending on the size of the company, number of units to be reviewed, availability of plant (or corporate) engineering, etc. Normally, one of leading persons as plant manager or his deputy undertakes responsibility for the performance of PSR. (Project manager is responding to him.)

PSR Project Management Team **–** The members of the Project Management Team, reporting through the PSR Project Leader will:

- Provide an overview of the work in his/her area of responsibility
- Act as senior technical resource responsible for ensuring that the review documentation, produced by the specialists, meets the PSR objective
- Ensure timely delivery of the review reports in accordance with the project plan.

The team should therefore typically consist of:

- representatives from the plant familiar with the operational aspects,
- safety experts with a broad knowledge of the safety issues and how they interact,
- a representative of the licensee's internal nuclear safety division,
- an engineer with experience of implementing plant modifications
- a member with experience of assessing the effectiveness of safety management systems and safety culture.

Internal/External Technical Experts **–** Reports covering the various aspects of the review will typically be prepared and verified by structural, plant, and safety analysis experts, either from within the licensee's organization or by external consultants.

Regulator **–** The role of the regulator in PSR is to define expectations at the start of the review, to agree to the scope of the review and to manage the regulatory assessment of the completed review submitted by the licensee. Throughout the entirety of the project there should be regular communication between the regulator and representatives of the licensee's PSR project management team, firstly to agree the scope of the review and thereafter to discuss progress with the review thereby ensuring continued alignment of expectations, with the aim of minimizing the possibility of unexpected findings from the regulator's assessment.

4.3 COMMUNICATIONS

It is incumbent on both the licensee and the regulatory body to develop adequate communication strategies at the outset, in order to provide information such as the purpose of the PSR project, work progress, roles and responsibilities, timelines, and project outcomes. Single points of contact would be established at this stage (see also Section 4.1).

The licensee and/or the regulatory body could communicate the outcomes to the government and the public in accordance with national legal requirements, custom and practice. Reporting arrangements required under international conventions will also apply.

An adequate communication strategy would normally cover:

a) The establishment of a licensee/regulator communications protocol,
b) Communications within the regulatory body and its supporting contractor organizations,
c) Communications within the licensee and its supporting contractor organizations, and
d) Consistent communications with other parties such as non-governmental organizations, various authorities that could be involved in, or affected by, the project, and the public.

One good practice, when developing the communications strategy, is to agree on reporting periodicity versus report type. For example, monthly or quarterly progress reports may be produced by the licensee, while “milestone” reports may be produced by the regulatory body, e.g. when a particular authorization is contemplated or given, or when a significant finding is identified. Other possibilities include press releases and/or a dedicated website. It is essential in all cases that licensee /regulator communications are held in a timely manner.

4.4 TECHNICAL SOURCES

In order to ensure that all contributors to the review are using consistent data, it is important to assemble all relevant data. This should be carried out at the start of the review jointly by operational and technical staff. The objective is to establish a single database of information to be used by all those involved in reviewing the plant safety and thereby to ensure consistency across all areas of the review. In addition to gathering historic data, predictions of likely future operation should be provided for the period to the next review in order to enable the progression of ageing mechanisms etc. to be predicted. This information may already exist in the ageing management programme. It is advisable to assemble the data as early as possible in the review phase or even as part of the preparation phase where this is practicable. In order to ensure consistency across the PSR, it is desirable to freeze the database at an appropriate time. Only if significant changes in data occur should further data be added exceptionally, otherwise changes may be accommodated at the next review.

Required data includes operational data such as primary circuit activity, numbers of scrams, pressure cycles, temperature cycles, results of testing and inspection etc. This data is normally available through the nuclear power plant performance records, and should be complemented by a shared understanding of the current design basis of the plant and also of the Final Safety Analysis Report (FSAR).

In order to establish the design basis, it may be necessary to consult the original architect engineer. If the design basis is not current, a separate project may be required for this purpose.

Some Member States do this during the PSR but due to the nature of this work, it is a large undertaking best done outside of the scope of the PSR.

FSAR, as well as the equipment qualification, maintenance frequencies and PSA, should be confirmed to be aligned with the current plant status. In case of inconsistency, FSAR should be revised in the frame of PSR.

Regarding of data required for the review, their character and availability is very different depending on relevant safety factor (area). For example, the sources of information for the review of the plant design are mainly available in the archive of the plant design and safety documentation. The review of plant management and administration needs to collect full scope of plant (and corporate) management documentation as regulations, polices, rules, directives, instructions, records, results of audits, peer-reviews and regulatory supervisions, etc.

4.5 REVIEW OF SAFETY FACTORS

Safety Guide NS-G-2.10 [3] identifies 14 safety factors which, if properly reviewed, should meet the objective of a PSR as given in paragraph 2.8 of NS-G-2.10. Although the safety factors are considered sufficient for a comprehensive review of the safety of a plant, NS-G-2.10 recognizes that the specific needs of a Member State and a particular nuclear power plant under consideration may require some variation in the set of safety factors (paragraph 4.2 or NS-G-2.10). Notwithstanding any variation, achieving the objective of the PSR is fundamental and should not be compromised. Therefore it is recommended that agreement be reached between the licensee and the regulator on the safety factors to be used and what their review will entail prior to the start of the review of safety factors. This includes agreement on the list of current international safety standards and practices to be considered in the review.

NS-G-2.10 groups the safety factors into five subject areas to facilitate the review. The groupings are based on strong linkages and interfaces between the safety factors within each group. Therefore the review of each of the safety factors within a group should take account of these linkages and they should not be carried out totally independent of one another, an example is Equipment Qualification and Ageing. In some cases topics are overlapping and can be dealt with in different safety factors (e.g. Plant actual conditions, Equipment Qualification and Ageing or Safety Performance and Radiological Impact on the Environment). However, the topics should be addressed only in one safety factor and referenced in the other one. This is, in particular, necessary when the reports on the single safety factors are submitted separately to the regulator and the whole information on all safety factors is still not available.

In addition, the results of one safety factor assessment may serve as input for another (Safety Performance is an input for deterministic and probabilistic safety analysis). Ultimately, it is the assessment of the individual safety factors, taking into account their interaction, which provides the global view needed for the overall assessment of nuclear power plant safety.

It should be noted, that not all Member States review all of the safety factors within their PSR. Some licensees have addressed some safety factors or parts of safety factors under other legal or licence instruments. However, the guidelines and safety factors presented in the IAEA Safety Guide [3] provide a useful check.

For each safety factor a review should be performed of the effectiveness of the associated programmes. This could include the review of the results of various previous audits, peer reviews and self assessments.

If any issues of major safety significance arise during the review phase, then these should be addressed immediately.

Further details of each of the fourteen safety factors are provided in the following subsections.

4.5.1 Safety factor 1: Plant design

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 scope of the review is to confirm the design basis for the plant and compare it to the current national regulatory requirements and current international safety standards and practices.

The first step of the review is to determine if sufficient information is available to define the design basis. At some older nuclear power plants documentation relating to the design and design basis was not supplied in full to the operator, or became obsolete with time. This is of particular importance for plants that have undergone many modifications over their lifetime and those for which record keeping has been less than satisfactory. The first PSRs revealed this issue and programmes were initiated for the reconstitution of the design basis, including the collection and update of the design information.

Definition of the references for the comparison is critical for the review. It is reasonable to select not only national requirements but also those design standards which are internationally accepted. For example, the safety requirements for design given in NS-R-1 [14] can be used as the reference for the design review.

According to Ref. [3] the review must cover the list of SSCs important to safety. Development of the list is a major task of the first PSR if no safety classification was previously established for the plant. The list of SSCs to be included in the PSR design review should receive the agreement of the regulator prior to the start of the review. In subsequent PSRs the list should be reviewed and modified if necessary.

The main result of the review should be the identification of the differences in plant design compared to current safety standards, and a determination of their safety significance in relation to the application of defence in depth. Different approaches have been used in the review of the plant design. For example some reviews followed the structure of the FSAR. The first PSRs identified significant safety issues and this led to important safety improvements at many plants.

Design basis information is incorporated into the FSAR and forms an integral part of the licensing basis of the plant. Therefore, the review of this safety factor in combination with the review of other safety factors (such as deterministic safety analysis) will contribute to the reconstitution of the design basis if not available previously, and form the basis for recommendations for modifications to improve plant safety.

The existence of an effective configuration management programme should be confirmed within the review of this safety factor. Keeping nuclear power plant documentation updated is very important for the continued safe operation of the plant. Licensees with good configuration management programmes find it easier to review this safety factor.

4.5.2 Safety factor 2: Actual condition of systems, structures and components

The objective of the review is to determine the actual condition of SSCs important to safety and whether it is adequate for them to meet their design requirements. In addition, the review should confirm that the condition of SSCs is properly documented.

The scope of the review is to determine the actual condition of the SSCs important to safety and to compare them against their design basis to confirm that they still meet their design basis assumptions. Where consistency with the design basis cannot be fully demonstrated, fitness for purpose of the SSC needs to be justified or corrective measures proposed. In addition, the effectiveness and adequacy of the condition monitoring programmes should be assessed to determine their adequacy and effectiveness for maintaining current the information regarding the condition of the SSCs.

According to Ref. [3] the review has to focus on the condition of those SSCs which were identified under the review of the safety factor ‘plant sesign’. However the condition of the facilities defined in the operating licence (such as the civil building structures and the waste management facilities) and their operation may have to be assessed also. The most important features of SSCs, such as the actual condition of a particular SSC, tend to be unit and even item-specific. In the case of multi-unit plants those SSCs common to all units do not normally require individual review for each unit. For plants utilizing a standard design and operation, the experience of some Member States indicates that the essential part of the review might be made on a fleet-level.

The detailed analysis of the condition of the SSCs may take into account modifications, changes in safety requirements and the design basis, ageing, equipment qualification, and obsolescence. This safety factor usually also considers the safety status of software-based systems including potential obsolescence.

Where compliance with the current design basis cannot be demonstrated, arguments may be provided to demonstrate the fitness-for-purpose of the SSC, or failing this, consideration is given to the practicability of carrying out a corrective action to rectify the shortfall. The first PSRs at many plants resulted in upgrading measures to eliminate the deviations from the required condition.

Experience has shown that it is beneficial to perform systematic plant walkdowns, carried out by a carefully selected team of plant experts, in order to confirm that the SSC’s current condition, configuration and qualification, comply with their designated safety requirements.

4.5.3 Safety factor 3: Equipment qualification

The objective of this review is to determine whether equipment important to safety remains capable of performing its designated safety function under all postulated service conditions, including fault conditions and their consequential environmental conditions throughout its installed service life. The review should include whether the reactor’s systems important to safety will perform their intended safety functions in accordance with design standards under normal operation environments, during events and hazard conditions.

The scope of the review of equipment qualification is to determine:

- That the plant design adequately identifies components requiring qualification
- Whether the required equipment is qualified to meet the design requirements
- Whether equipment qualification is being maintained by ongoing measures which are clearly documented.

The first PSR at many plants indicated:

a) Some lack of initial qualification
b) The need for some re-qualification arising from changes to the plant design basis (such as revised seismic qualification levels) and changes to environmental parameters (such as more severe environmental conditions predicted by new safety analysis).

Qualification and re-qualification projects (corrective programmes) were implemented at many plants to deal with this issue. These projects included identification of the activities necessary to ensure adequate equipment qualification such as; listing of SSCs to be qualified, the qualified functions of each SSC, environmental conditions to be taken into account, selection of qualification methods, documentation of the qualification and measures required to maintain qualification. In addition, as discussed above, plant walkdowns of installed qualified equipment may be performed to confirm the assumptions of qualified configuration are still valid (for example, no abnormal conditions such as missing or loose bolts and covers, exposed wiring or damaged flexible conduits exist). This information can be obtained during the walkdowns for the condition assessments in support of the actual condition of SSC's safety factor report.

A programme demonstrating the continued qualification of equipment throughout the life of the plant has been established by many Member States. This can be regarded as a specific ageing management programme which includes activities such as monitoring of environmental conditions relevant to the qualification of the equipment, monitoring and forecasting of degradation, and replacement of worn or degraded components before equipment qualification is jeopardized. The programme also includes the input of any changes in qualification requirements arising since the last PSR and the qualification or re-qualification of any equipment this may necessitate. The second and subsequent PSRs verify the completeness of the list of qualified SSCs and review the effectiveness of the programme for maintaining the equipment qualified to perform its designated safety function for the life of the plant.

4.5.4 Safety factor 4: Ageing

The objective of the review is to determine whether ageing in a nuclear power plant is being effectively managed so that required safety functions are maintained, and whether an effective ageing management programme is in place for future plant operation.

The scope of this safety factor is to review the comprehensive ageing management programme established at the plant. The review should demonstrate that:

- A systematic and effective comprehensive ageing management programme is in place
- The comprehensive ageing management programme covers SSCs important to safety, and also any non-safety related SSCs whose failure might inhibit or adversely affect a safety function,
- All degradation mechanisms are identified, and the models used to predict the evolution and advancement of degradation are supported in accordance with current accepted practices pertaining to age related degradation.
- Adequate measures are taken to monitor and control the ageing processes,
- The comprehensive ageing management programme ensures the continued safe operation for the next PSR period, and to the end of life of the plant.

It should be noted that the scope refers to a comprehensive ageing management programme which is in reality a compilation of many individual smaller programmes covering such areas as steam generators and equipment qualification.

An ageing management programme usually demonstrates how to detect and predict ageing degradation that may affect SSC's safety functions and lifetime and identifies appropriate measures for their maintenance. ageing management programmes usually include: programme description, evaluation and technical basis; plans for the reliability and availability of SSCs; the detection and mitigation of ageing; and actual physical conditions of the structures and components. The review, in general, focuses on the integrated system performance for the systems important to safety and on the results of periodic inspection programmes and trends in certain important safety parameters.

At many plants, the first PSR identified the need for the development and implementation of a comprehensive ageing management programme. In some Member States such as Japan and France, the PSRs performed just prior to thirty years operation, are focused on the completeness and effectiveness of a comprehensive ageing management programme for ensuring the continuation of safe operation.

4.5.5 Safety factor 5: Deterministic safety analysis

The objective of the review of the deterministic safety analysis is to determine to what extent the existing deterministic safety analysis remains valid when the following aspects have been taken into account: actual design of the plant, the actual conditions of SSCs and their predicted state at the end of the period covered by the PSR, current deterministic methods, and current safety standards.

The scope of the review is to compare the deterministic safety analysis with current standards and regulatory requirements and to update the analysis when necessary to ensure that it is based on the actual design and meets current codes and standards. The deterministic approach checks the status of plant safety with regard to the defence in depth concept of barriers to radiological releases and has to take full consideration of the safety role of procedural and human factors aspects.

It is important to recognise the distinction between within design basis safety analysis and that for the beyond design basis situation. Design basis analysis is based upon a well defined schedule of initiating events with a well defined progression and fault consequences; the plant and operator responses are both systematic and predictable. In beyond design basis faults, the progression is less predictable and a more symptom-based approach is required, requiring a greater flexibility of response. It is therefore advised that the reviews of the respective within design basis and beyond design basis safety analyses are performed separately. For example, design basis analysis is usually based more on conservative approaches whereas best-estimate plus uncertainties calculations may be conducted for beyond design situations.

If necessary, the safety analysis has to be updated using the latest data and methodologies. For the deterministic analysis, one possible approach for assessing adequacy of defence in depth is provided in the IAEA Safety Reports Series No 12 [15]; this approach emphasizes the greater priority to be given to accident prevention over mitigation. The first activity in performing the safety analysis is to review the completeness of the schedule of potential initiating events taking into consideration the experience from both the nuclear power plant and other licensee/international experience feedback. The review should be comprehensive, containing both potential plant/operator initiated events and those due to internal and external event sources (see safety factor 7).

When a comprehensive schedule of potential initiating events has been established for the respective plant, it is then advisable to review the performance data to determine any changes in reliability for systems important to safety and changes in initiating event frequency and /or magnitude. Moreover, having reviewed this safety factor it is necessary to check the relevant procedures when procedural steps are assumed in this safety analysis.

4.5.6 Safety factor 6: Probabilistic safety analysis

The objective of the review of PSA is to determine to what extent the existing PSA remains valid as a representative model of the plant taking into account the actual plant status including changes in the design and operation of the plant, new technical information, current methods and computer tools as well as new generic or plant specific operational data.

The first activity in the review of PSA is to check the completeness of the list of potential initiating events taking into consideration the experience from both the nuclear power plant and other licensee/international experience feedback. The list should be comprehensive, containing both potential plant/operator initiated events and those due to internal and external event sources (see safety factor 7).

The review should ensure that safety margins identified in the PSA are considered carefully, taking into account calculated core damage frequency and possible radiological consequences. It is reasonable that these calculations are performed separately for design basis accidents and beyond design basis situations due to the different characteristics of the respective analyses and possible corrective actions, and in accordance with national regulations.

PSA should be performed or updated, using the latest techniques, which model both the safety systems and significant human factors aspects in an integrated approach; the potential for the operator to contribute to faults, also to mitigate them should be recognised. If a level 2 PSA is performed, the review should take into consideration validated scientific advances in terms of transient analysis techniques and radiological consequences assessment and also any significant changes in population density or patterns within the immediate vicinity of the nuclear power plant. The consistency of the accident management programme for beyond design basis accidents with PSA results have to be checked. Level 2 PSAs are useful to check the adequacy of implemented or planned accident measures.

When a comprehensive list of potential initiating events has been established for the respective plant, it is then advisable to review the safety performance data to determine any changes in reliability for systems essential to safety and changes in initiating event frequency and/or magnitude. Moreover, having reviewed this safety factor it is necessary to check the relevant procedures when procedural steps are assumed in this safety analysis.

4.5.7 Safety factor 7: Hazard analysis

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

The scope includes establishing a list of hazards relevant for the respective plant. The review has to check the completeness of the list based on current standards and taking into consideration experience from both the nuclear power plant and other licensee/international experience feedback.

The appendix to NS-G-2.10 [3] contains a list of the hazards to be considered by the PSR.

For those hazards relevant for the plant, the review of the safety factor has to demonstrate either a sufficiently low probability of the hazard or the adequacy of preventive and mitigating measures by using current analytical techniques and data. For that purpose, the results of the deterministic and particularly probabilistic safety analyses are required.

The PSR hazard review may include as appropriate the following:

- Confirmation that there has been no significant ageing of qualified SSCs which could undermine their hazard withstand capability during the period of operation covered by the PSR, e.g. check condition of fire barriers, sea flooding defences, corrosion of seismic restraints. Supporting information to this can be obtained from the walkdowns for the condition assessments in support of the actual condition of SSC’s safety factor report.
- Confirmation that there have been no modifications implemented during the review period which have resulted in the introduction of new hazards to the nuclear power plant site, e.g. pressurized storage of hazardous or inflammable liquids/gases. In the event that new sources have been introduced, an assessment should be performed to demonstrate that there is an appropriate level of protection to ensure nuclear safety and the FSAR updated accordingly.
- Confirmation that there have been no modifications introduced during the previous period of operation which could either directly or indirectly (i.e. via interaction) undermine the hazard withstand capability of any of the claimed SSCs.
- Confirmation that the defence in depth/plant configuration claimed as protection against each of the hazards is consistent with the assumptions in the FSAR and other supporting documents.
- Assessment of the impact of any changes in hazard levels, due for example to changes in hazard magnitude derivation methodologies, climate changes which could affect sea levels, wind speeds and extreme ambient temperatures or changes in air traffic levels or patterns. In the event that the hazard level has changed the claimed SSCs should be re-assessed to confirm their hazard withstand capability.
- Review of recent developments in the vicinity of the nuclear power plant site to confirm that there has been no new industrial hazard threats (e.g. chemical plant) introduced during the previous period of operation. In the event that any new potential hazard source is identified, an assessment should be performed to demonstrate that there is an

appropriate level of protection to ensure nuclear safety and the FSAR updated accordingly.

- Confirmation that the effects of credible consequential hazards (e.g. seismically induced fire) have been considered.
- Confirmation that the hazard information in the equipment qualification schedule is accurate and consistent with the current qualification status of the SSCs.
- Confirmation that the implications of any significant hazard events that have occurred either at the nuclear power plant site or elsewhere (via the various operational experience media) have been appropriately analysed and action taken as appropriate.

4.5.8 Safety factor 8: Safety performance

The objective of the review of safety performance is to assess the overall safety performance of the nuclear power plant through a review and trend analysis of, for example, operating experience (site-specific and industry), maintenance records, radiation situation of the reactor-units, unplanned outages and equipment performance, operational events or incidents, peer review activities, regulatory inspections, and quality assurance audit findings. The review also includes a review of radiation exposure of the personnel, for example some Member States include a review of the ten years trend of radiation doses to plant personnel. In addition, off-site radiation and radioactive effluent data is reviewed.

The safety performance review activities are typically of sufficient scope to determine whether the selected safety performance indicators are adequate, the criteria by which these indicators are judged are appropriate and aligned with current international standards and best practises. Furthermore, the trends should be reviewed to identify any shortcomings and to confirm that there are management systems in force to restore, maintain, and improve safety performance.

The review has to identify any shortfalls in performance as evidenced, for example, by trends indicating reduced plant reliability. In the event of shortfalls being identified, determine whether measures/modifications have been introduced to restore performance and assess whether measures taken have been successful in restoring performance.

The review should confirm that the safety related incidents are investigated using root cause analysis and lessons learned from investigation of these incidents are fed back into the conduct of operations and maintenance. The review should also confirm that the results of the root cause analysis are also used to minimize the chances of the same incident reoccurring.

Once the safety performance is assessed and benchmarked through the PSR process, performance improvements and revised performance metrics can be considered to help ensure continued and improved safety performance.

4.5.9 Safety factor 9: Use of experience from other nuclear power plants and research findings

The objective of this review is to determine whether there is adequate feedback of safety experience from other nuclear power plants and research findings.

The scope is to review the programmes for retrieval and dispersal of operational experience feedback and research findings from sources within the nuclear power plant organization, national sources and international sources in accordance with current standards and practices and to determine the adequacy and effectiveness of the established systems.

In order to determine the effectiveness of the systems, the historical operational experience feedback records should be reviewed and the response of the nuclear power plant in addressing issues of high safety significance should be assessed.

Experience has shown that feedback from other plants is usually received and evaluated, but arrangements for the receipt of information on findings from relevant research programmes are less than adequate.

4.5.10 Safety factor 10: Organization and administration

The root cause of the majority of events on nuclear power plants can be traced to some organizational failure. The objective of the review of organization and administration is therefore to determine whether the organization and administration are adequate for the safe operation of the nuclear power plant.

The scope of the review is to check the adequacy and effectiveness of the management systems in maintaining a strong safety culture, which supports and maintains the safe operation of the nuclear power plant. The review may be performed either internally by the nuclear power plant operator or by an external contractor; however, if the review is performed internally it is beneficial for an external peer review to be conducted to ensure an appropriate level of independence.

The review should consider the adequacy of the manner in which the nuclear power plant is managed, including interfaces and responsibilities, in terms of their impact on nuclear safety. A good practice is an open, blame free reporting culture supported by internal and external audits, e.g. WANO and IAEA missions (e.g. OSART, IRRS, SCART, etc.).

The PSR review of the organization and administration may include as appropriate the following:

- The quality management system, which includes a hierarchy of documentation which embraces all levels of the organization, including the corporate level, and an effective staff structure designed to meet the requirements of safe, reliable operation of the nuclear power plant.
- The continuous improvement cycle and other programmes supporting safety culture, see also Refs [8,11] for further guidance.
- The adequacy of the organizational change control process.
- The control of work procedures for hire of contractors or contracting out of work to other organizations.
- Trends in key human performance indicators which monitor, for example, procedural deviations or violations, reportable events, maintenance and operator induced errors, lost time accidents.
- Recruitment policy looking for evidence of a forward looking, systematic approach which ensures the maintenance of appropriate numbers of staff in key skills areas.
- Staff succession arrangements looking for evidence of a forward looking plan which anticipates future vacancies resulting from staff turnover due, for example, to or advancement or retirement.
- Staff training arrangements, looking for evidence of a systematic approach to training, including the establishment of training plans for all staff, based on a systematic training needs analysis. Evidence should be sought of regular review and update of training

plans. A key indicator of the health of the training programme would be the number of training events missed by staff.

- Review the outcome of audits/peer reviews and actions taken in response to their findings/areas for improvement

4.5.11 Safety factor 11: Procedures

The objective of the review of the plant's procedures is to determine whether they are of an adequate quality and, more importantly, to determine if they satisfy the intent of the associated programmes, which may have been submitted for regulatory review and approval during the plant's licensing stage. High level procedures such as maintenance and training programmes are identified and reviewed prior to the review of lower level procedures that outline how to perform the work.

Procedures to be reviewed are those which are of safety significance. The significance of procedures can be evaluated deterministically according to the defence in depth concept; additionally, a PSA can be a useful tool for identifying significant operator actions and associated procedures.

During the PSR the scope of the review includes the procedure's comprehensiveness, validation, clarity, and approval. A given procedure should furthermore be subject to rigorous change control, reflect current practice, be relevant to the actual plant, give due consideration to human factors aspects, and have an identified owner, who would be responsible for its maintenance and update. The use of tables and/or flowcharts is recommended where appropriate.

Safety significant procedures cover the areas of normal and abnormal operation, maintenance, modifications, inspection and testing including placing equipment back in service, work permits, and radiation protection.

Finally, the review ensures that procedures do not place conflicting/competing requirements or demands on the operator, and take into consideration any relevant claims made in PSAs or safety analyses. This may be discussed in other safety factors, e.g. Safety Performance, Human Factors or Organization and Administration, and therefore the corrective actions may be identified as the result of one or more of these safety factor reviews.

4.5.12 Safety factor 12: Human factors

The objective of the review of human factors is to determine the status of the various human factors that may affect the safe operation of the nuclear power plant.

The scope of this safety factor is not only to review the status of management of the various human factors that could affect the safe operation of power plants, but it may also identify areas of human performance where such activities can significantly affect nuclear safety, if not addressed in the safety analysis area, and assess them against current standards and practices. The review takes into consideration aspects of human factors including: staff qualifications, hiring, and training of employees; employee performance enhancement programmes; employee concerns or ombudsman programme and also human-machine interface.

For example, for some Member States such as the Republic of Korea, the human factors safety factor review includes the following elements:

- Staffing levels for the operation of the nuclear power plant recognizing absence, shift working, and overtime restrictions
- Availability of qualified staff on duty at all times.
- Programmes for initial, refresher and upgrade training, including the use of simulators.
- Human information requirements and workload.
- Human-system interface including control room and other workstation design.

As an example, the chapter on human factors as part of the PSR Scope and Methodology Document of the Republic of Korea is provided in Annex V.
In some Member States, regulatory guidance on human factors engineering has been issued and their PSRs included this in the review of this safety factor topic.

In general, since human factors are important elements of safety culture, the adequacy and effectiveness of the respective programmes are also reviewed.

In many plants, the review of human factors was carried out with the assistance of appropriately qualified external specialists. Because of the difficulties associated with carrying out an objective review of what is essentially its own human performance, the licensee may decide that specific elements of the review can only be carried out by external advisors or experts.

Due to the overlap between the organization and administration, procedures and human factors, in some Member States these three safety factors are reviewed together and results summarized in an integrated report. There may also be an interface with probabilistic safety analysis.

4.5.13 Safety factor 13: Emergency planning

The objective of the review of emergency planning is to determine (a) whether the licensee has adequate plans, staff, facilities and equipment for dealing with emergencies and (b) whether the licensee’s arrangements have been adequately co-ordinated with local and national systems and are regularly exercised.

The scope of the emergency planning review should be sufficient to adequately assess the emergency planning process against national and international standards and regulations. The review may consider the local emergency preparedness, exercise results, and subsequent corrective actions taken. The review may also consider whether the nuclear power plant’s emergency planning arrangements are adequate, taking into consideration the results of the safety analysis, the latest radiological consequences data and analysis methodologies and changes in population density/patterns in the vicinity of the nuclear power plant. The review typically considers the adequacy of countermeasures and evacuation arrangements, and the arrangements for coordinating/communicating with local emergency services, the media and public during an emergency. Due to the period of a PSR, the trends of improvement measures resulting from the exercises and the drills should be part of the review.

4.5.14 Safety factor 14: Radiological impact on the environment

The objective of the review of the radiological impact of the nuclear power plant is to determine whether the licensee has an adequate programme for surveillance of the radiological impact of the plant on the environment.

The scope of the review is to determine whether the management programme is adequate and the documentation of environmental data is complete. The levels of authorized site discharges should be compared with national and international limits and it should be checked whether all reasonably practicable measures are being taken to minimize cumulative doses to workers, contractors and the public.

The review should summarize initiatives and measures taken to reduce/minimize such releases. Ideally, the review will show a trend of stable or reducing annual discharge levels in all areas.

With regard to site incidents, the review should identify measures taken in response, in order to minimize the possibility of such events recurring.

Major input data for the review are data on releases of radioactivity to land, sea and air, which occur as part of normal day-to-day operation and due to incidents, on doses to workers and contractors at the nuclear power plant, also to the local population in the vicinity of the nuclear power plant. Parts of this review might also be performed within the safety factor ‘safety performance’. The results of the review may require changes to the FSAR as part of the corrective action plan.

4.6 GLOBAL ASSESSMENT

The process of PSR consists of evaluation of individual safety factors (areas), whose results are documented in ‘area reports’ and a global assessment with resulting proposal of corrective actions.

The global assessment in the PSR is a consolidation exercise performed by a small group of experts (5 or 6 people) with a combined breadth of knowledge of the plant, the safety analysis, SSCs, I&C and internal/external hazards. The group may therefore comprise representatives of both the nuclear power plant and its technical support organizations. For example, in Canada, the global assessment team was comprised of senior industry experts with either utility or regulatory experience to perform the global assessment for one nuclear power plant.

On completion of all individual safety factor reviews, the licensee performs an overall assessment of plant safety taking into account all findings, corrective actions, and plant strengths identified by the PSR. Each safety factor report and its results are reviewed and compared to the other safety factor reports to identify any duplication and to resolve any inconsistencies. This is especially important if the safety factor reports have different authors. From the development of a consolidated list of findings it may be possible to group similar findings with a view to optimizing corrective actions.

Other supporting information that may be considered for the review includes:

- Regulatory requirements and PSR scope and methodology documents
- Regulator feedback for previously submitted PSR documents
- Regulatory issues identified prior to or during the PSR
- Reference material for the above reports

By considering the safety factor issues in their entirety, the global assessment can identify issues which when considered in isolation, may appear acceptable but when taken together may prove to be unacceptable. This is particularly relevant in considering human and organizational factors. In some cases a number of issues which require a common corrective action/safety enhancement to resolve them may be combined in the global assessment. It is also possible in some cases that corrective actions/safety enhancements may not be necessary for issues that are balanced by relative plant strengths, although the resolution of all issues should take account of the ALARA principle.

A key activity of the global assessment is to screen issues according to their safety significance in order to prioritize implementation of the corrective actions/safety enhancement programme. In some Member States the issues are prioritized prior to the global assessment and then reviewed during the global assessment.

It is important that the global assessment provides an overall conclusion on the risk associated with continued operation, taking into account committed actions and dispositions for issues for which there is no corrective action.

The conclusions of the global assessment group should be carefully documented to provide a transparent and auditable trail for future reference and the results recorded in the global assessment report.

On completion of the global assessment it may be necessary to revise and re-issue the safety factor reports to reflect decisions/changes arising from the global assessment. The final PSR report usually includes the global assessment summary.

4.7 REGULATOR’S ASSESSMENT

The regulatory body has the responsibility to review the results of the PSR and the consequential corrective actions and/or safety improvements, and to take appropriate regulatory actions. It may also be responsible for reporting the outcome of the PSR to the national government and the general public.

On completion of the review stage, the regulator may conduct an independent assessment of key aspects of the PSR, in some cases involving external (possibly international) experts from technical support organizations (TSOs). This can lead to queries and points of clarification being raised.

During the final assessment process, the regulatory body communicates with the licensee to clarify issues, including any additional issues identified by the assessor, and to acquire any necessary additional information. The results of these interactions should be documented for future reference.

For some Member States, an assessment report is prepared that clearly identifies all significant issues which need to be resolved. The regulatory body may also prepare a project report which identifies each issue requiring a corrective action and/or safety improvement and includes required dates for completion. These dates are usually negotiated with the licensee during several formal meetings leading to a commitment from the licensee. These commitments may be documented in an integrated implementation plan.

It is important that auditable systems are set up by both the regulator and licensee to monitor the status of incoming and outgoing correspondence relating to the regulator’s assessment and that any issues arising are added to the full list of issues to be resolved.

Because the process of PSR takes approximately 2-3 years it is very useful to keep good levels of communication between regulator and licensee. It is therefore considered to be a good practice to have single point(s) of contact between the licensee and the regulator.

4.8 PROGRAMME FOR IMPLEMENTATION OF CORRECTIVE ACTIONS

Following the completion of the global assessment, a prioritized list of safety significant findings will have been developed. From this list, appropriate corrective actions to address the safety issues are defined and an adequately resourced programme is prepared for their implementation. In some cases it may be necessary to conduct a preliminary assessment in order to determine the scope of the work required before a committed programme can be declared.

Solutions to resolve the various issues may involve a modification to the plant, a modification to procedure(s), further analysis or a combination of these. It is essential that as many of the potential options for resolving issues are identified to enable optimization of solutions. Member States with a good configuration management process will utilize their process to ensure that modifications to plants or procedures do not create adverse safety impacts.

A good configuration management process will also ensure that, as a minimum, the following documentation is updated:

- FSAR or safety case documents
- Design basis documents
- Procedures
- Technical specifications
- Maintenance documents
- Plant drawings
- Inspection and test schedules.

Different approaches exist for the prioritization of corrective actions. A detailed description of this topic is given in Ref. [15]. Such a judgement process can be based on deterministic analyses and criteria and/or the results of a PSA; the application of engineering judgement is also an important factor in this process.

One Member State’s approach is the risk-informed process where the risk of plant operation is reduced to such a level that it can be said to be as low as reasonably practicable (ALARP) i.e., the effort required to reduce the risk further is not justified against the benefit that would be gained. Such an ALARP assessment requires consideration of all factors relevant to the safety issue. Firstly the potential options for resolving the issue are identified. For each option, both the benefits and disadvantages are listed in order to compare them and to establish the best solution.

All the factors relevant to each issue, both qualitative and quantitative are considered. The qualitative part of the assessment identifies not only the benefits and disadvantages of each option following implementation of the enhancement but also the potential disadvantages *during* implementation; for example dose to workers.

The quantitative assessment is based on the cost/benefit approach which takes into consideration all the costs associated with the design and implementation of each potential option and the associated benefits in terms of the potential risk averted by the enhancement;

i.e. the reduction in accident cost. In judging the best option, due consideration is given to both the qualitative and quantitative factors.

From the experiences in conducting PSRs, Member States have identified the following examples of good practice for consideration in connection with the corrective actions programme:

i) Where other licensees experience of implementing corrective actions on similar nuclear power plants is available, this is considered as a first step.
ii) For some Member States the regulatory assessment is considered before finalizing the programme for implementation.
iii) Higher management approval of the overall scope, costs and resources is obtained before declaring a committed corrective action implementation programme.

Although implementation of the corrective action programme may not be included within the PSR, it is noted that in some Member States, implementation of the corrective actions is an integral part of the PSR. However, the implementation of the corrective actions will be performed in accordance with the usual licensing procedure for changes.

5. BENEFITS AND RESOURCES OF PSR

In the following, the main benefits and direct costs of PSR are presented

5.1 BENEFITS OF PSR

– PSR can be a helpful instrument for plant licence renewal depending on national legal framework.
– PSR gives assurance that the plant status is acceptable regarding current safety requirements.
– PSR is an appropriate tool for enhancing safety of the plant.
– PSR gives further assurance that the plant is safe to continue operating until the next PSR, subject to implementation of the corrective actions programme.
– PSR provides a means by which the safety of an nuclear power plant can be justified to the public.
– PSR ensures alignment of the safety documentation with the plant status and clarifies the licensing/design basis.
– PSR is a good tool for identifying back-fitting priorities.
– PSR helps to justify later life time extensions.
– PSR provides information for the nuclear power plant licensee to make investment decisions.
– PSR creates a common understanding of safety issues for both the regulatory and nuclear power plant licensee staff.
– PSR improves communications between the regulatory body and the nuclear power plant licensee.
– PSR is a source of public information on nuclear safety.
– The formation of a focused PSR team, which has an overview of all nuclear safety aspects of the plant, creates a wider knowledge and understanding and increases the

level of corporate cross competence on safety issues, thereby improving licensee safety culture and team spirit.

– PSR results form a good basis for improving staff training and education programmes, for preservation of the knowledge base and for knowledge transfer to the next generation of staff.

The benefit of PSR might also be visible by the fact that some Member States apply this approach also for other nuclear installations such as research reactors, fuel facilities and defence facilities.

5.2 RESOURCE EXPENDITURE

From the review of Member States' experience it is clear that overall costs for the various phases of PSR vary considerably; this is due to many factors, but more particularly due to variation in member states manpower costs. Caution should therefore be exercised in attempting to draw firm conclusions regarding monetary costs. A more appropriate approach is to compare the effort required for various aspects of PSR in terms of man-years (My) expended. Typical average estimates are as follows:

Probabilistic safety analysis	10-12 My,
Recovery of design basis information (including revision of FSAR)	~150 My,
PSR (review phase only, depends on age of nuclear power plant)	~50-150 My.

APPENDIX

SUMMARY OF MEMBER STATES EXPERIENCE IN IMPLEMENTING PSR

This summary has been made using information given by the following Member States (MS) answering the questionnaire: Belgium, Brazil, Bulgaria, Canada, China, Czech Republic, France, Germany, India, Japan, Hungary, Republic of Korea, Lithuania, Mexico, Netherlands, Pakistan, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, and UK.

Topic/Question	Summary
1. Define the legal basis for PSR and its role within the normal licensing process.	Majority of MS established regulatory requirement on PSR In some MS PSR is a voluntary activity of the licensee. In some MS PSR is a complementary tool to the existing regulatory control tools. General, overall assessment of plant safety, and a demonstration for compliance with current licensing basis, and basis for modifications. In the MS where the plants have permanent license, PSR is the basis of prolongation of the operational license. In some countries (Republic of Korea, Spain, Hungary), PSR is a current licensing basis (CLB) requirement and has a specific role in the licence renewal (LR) process, i.e. in Spain PSR is considered as complementary the LR documentation.
2. Do PSRs in your country ensure the design basis remains valid, or, if not fully recorded, require its definition/recovery as part of PSR arrangements?	In some countries (e.g. UK, Hungary, Slovakia, Czech Rep., Ukraine), lack of design basis (DB) information was identified during the first PSR. Plant operators have mainly design documentation without justification available. A basic scope of DB information is available in FSAR, which is updated on regular basis. Due to modernization, some parts of the original design were subjects of deep analysis performed with the participation of the original principal designers. But, a consolidated full scope (safety) design basis document (DBD) is not still available. In countries where DB information (in form of FSAR or other) is available, the actual plant status is compared with DB in frame of the PSR. The deviations are assessed. Critical areas (e.g. the most frequent incidents, events) are assessed whether they are originated by the design (Germany). In other MS the PSR covers also the DB a priori. In all MS the DB is compared to the actual regulations (even more, the newest requirements and standards). Therefore, the PSR (directly or indirectly) is a tool for checking the validity of DB. In some MS the first PSR was an attempt to refresh the DB information. (DB reconstitution projects were initiated after the first PSR.)

3. What is the scope of PSR (e.g. as defined by IAEA safety factors)?	Only a few MS (e.g. China, Hungary, Slovakia, Czech Rep.) followed strictly the IAEA safety factor approach and the scope of the review. Safety goals or safety cases to be reviewed were defined in the national/regulatory or utility PSR documents. However, if the different existing programmes and reviews were credited, all safety factors could be covered by the MS PSRs and review practices. The first PSRs of some MS were specific, e.g. they had broader scope than defined in the IAEA Guideline, just to compensate all lacking information.
4. Have national guidelines on PSR been issued. If yes by whom? (i.e. regulator or licensee).	In many MS national guidelines have been developed. Different cases in MS practice can be distinguished: Issued by regulators Developed by the licensee and approved/accepted by the regulators Utility PSR document, project or QA plan In case of national guidelines issued by the regulator, those were based mainly on translated IAEA safety guide on PSR (China, Czech Republic, Slovakia).
5. What aspects are addressed in National Guidelines?	If national guidelines exist, this is mostly in line with the general recommendations of the IAEA guideline: The national regulation defines, e.g. the objective, scope, basic requirements, QA requirements, form and content of the report, conditions related to licence
6. What is the type and scope of PSR analysis (e.g. deterministic, probabilistic, level of PSA) and what were your safety goals (deterministic and/or probabilistic criteria)?	Deterministic (extended) safety analysis Review of external/internal hazards PSA (level 1, in a few cases level 2) Risk in shut-down condition Severe accidents (in some cases, e.g. Hungary) maintenance/survilanse/inservice inspection/test and ageing management programmes In some MS ongoing programmes covers certain aspects of safety. Mainly deterministic goals and criteria as per SAR or CLB Defence in depth criteria as defined in IAEA publications In some countries core damage frequency (CDF) goals.
7. Did the regulator and licensees form dedicated PSR teams within their respective organizations and what additional resources were required for PSR?	The licensees organized the PSR in different forms: PSR project Fleet-level performance and implementation Teamwork Different levels of involvement of the TSO (e.g. Hungary) and vendors (e.g. Slovenia). Some parts of a PSR (human factors, organization and management) were mainly performed by external reviewers. Based on the (limited) capacity of own technical support, some operators indicate that the next PSRs will be mainly outsourced. The regulators also organized teams for PSR but depending on their own capacity some of them did not keep contacts with reviewers in the course of the review due to another (regulatory) activity.

8. Give a brief statement on how you reached agreement with the regulator on addressing corrective actions? How does cost-benefit play a role?	• licensee submittals, proposals/suggestions for corrective measures • regulator evaluation, request on corrections • final consultation • regulatory approval Mainly, cost -benefit aspects were not presented important for the negotiations between operator and regulator.
9. Did you prepare any public documentation for PSR? If yes, what form/type?	In some MS short summary documents for public were released (UK). In some MS the whole document placed in the "reading rooms" or home-pages due to legal obligations of the operator.
10. What is the connection between the PSR and Final Safety Analysis Report?	In some MS the FSAR was reviewed or renewed in the frame of first PSR. In some cases the first PSR initiated the FSAR update. Practically in all MS the FSAR is renewed in the frame of after the PSR (taking into account the changes of DB, renewed safety analysis, modifications). FSAR is used for the reference in MS where the FSAR could be considered as complete and valid.
11. What were the durations (years) and costs (human-years) of the respective review and corrective action phases of PSR?	1-2 years review 0.5-1 years approval Implementation of corrective actions mainly 1-3 years, in some cases up to 6 years. The duration of the implementation phase depends on the safety relevance and assessed urgency of the respective corrective action.
12. Summarize the differences between the first PSR and the next one and the changes you will make to future PSRs based on your experience with the first PSR.	Usually the first PSR was focused on the updating of DB information, review of FSAR, evaluation of modifications, etc. Corrective actions were mainly focused on modernization and safety upgrading of the plant technology, fire protection, seismic reinforcement, resistance against extreme climatic effects as flooding, etc. Not enough information to make general statement about the second PSR because the preparation of the second PSR is commencing now in many MS. It is expected that the second and subsequent PSR will focus on overall safety assessment in light of long term tendencies especially ageing, additional insights from PSA, but also on soft functions as organization and human factors. Better definition of requirements needed. Demonstration of conformity has to be shortened (because the updated FSAR is the tool for this purpose). In some MS the basis of change of the national requirements on PSR is the IAEA NS-G-2.10. Where the updating of plant documents (FSAR) is performed in the frame of regular configuration management (CM) or the regular (annual) update of FSAR is a requirement, the activities related to FSAR and PSR will be separated to avoid the overlapping (e.g. Czech Rep., Hungary).

13. Does PSR find problem areas that would not normally be identified through normal process? Is PSR worthwhile?	Main advantage of the PSR is that it gives an overall picture. In the frame of PSR the licensee and the authority can see the issues (mostly known before PSR) in right context with their safety significance and contribution to safety (CDF). Normally, the supervisory process has to recognize any significant safety problem. PSR is a worthwhile tool because it provides a systematic comprehensive integrated picture of the plant safety level **at the same time.** PSR provides opportunity for identification of the deviations between national and international practices (e.g. in Czech Rep.).
14. Give examples of significant corrective actions resulting from the first PSR and from subsequent PSRs.	MS provided plenty of examples, e.g. in case of WWERs: Relocation or protection of auxiliary emergency feed-water system; Protection of sumps; Seismic upgrading measures e.g. in Switzerland and France, improvement of fire protection, feed and bleed, emergency power supply, seismic re-qualification
15. Give examples of managerial decisions as a result of PSR?	MS provided plenty of examples, e.g. • development of symptom based operating procedures • establishing maintenance training centre • extension of ISI and ageing management programmes.
16. Does the operating organization have a configuration management policy? (New question)	Some countries reported the existence of CM policy, even not as a formal document. In some countries following the US terminology the CM system is being used as in Canada, Mexico, India, China and Pakistan. In other countries, a typical operating organization has a process in order to ensure that the plant documentation is in compliance with the current plant design. The term configuration management is mainly not used for this task.
17) The IAEA standard permits crediting of other inspections. How is this implemented in your country and what are your experiences in that respect?	MS refer to the inspections made by IAEA (OSART) WANO, etc. The lessons learned from internal and external (international) inspections and reviews were taken into account (e.g. Slovakia, Hungary, Czech Rep., Pakistan). In Netherlands, the results of audits as WANO or OSART will be used as input for the definition of the scope of PSR. Main purpose of the PSR is to assess the results of the inspections, and draw conclusion regarding their efficiency and current safety level and evaluate the tendency for the next PSR period.

REFERENCES

[1] EUROPEAN ATOMIC ENERGY COMMUNITY, FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR ORGANIZATION, INTERNATIONAL MARITIME ORGANIZATION, OECD NUCLEAR ENERGY AGENCY, PAN AMERICAN HEALTH ORGANIZATION, UNITED NATIONS ENVIRONMENT PROGRAMME, WORLD HEALTH ORGANIZATION, Fundamental Safety Principles: Safety Fundamentals, IAEA Safety Standards Series No. SF-1, IAEA, Vienna (2006).

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Periodic Safety Review of Operational Nuclear Power Plants: A Safety Guide, Safety Series No. 50-SG-O12, IAEA, Vienna (1994).

[3] INTERNATIONAL ATOMIC ENERGY AGENCY, Periodic Safety Review of Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-2.10, IAEA, Vienna (2003).

[4] WESTERN EUROPEAN NUCLEAR REGULATORS' ASSOCIATION, WENRA Reactor Safety Reference Levels, Brussels (January 2007).

[5] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety Assessment and Verification for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-1.2, IAEA, Vienna (2001).

[6] INTERNATIONAL NUCLEAR SAFETY ADVISORY GROUP, Defence in Depth in Nuclear Safety, INSAG-10, IAEA, Vienna (1996).

[7] INTERNATIONAL ATOMIC ENERGY AGENCY, Assessment of Defence in Depth for Nuclear Power Plants, Safety Reports Series No. 46, IAEA, Vienna (2005).

[8] INTERNATIONAL NUCLEAR SAFETY ADVISORY GROUP, Safety Culture, Safety Series No. 75-INSAG-4, IAEA, Vienna (1991)

[9] INTERNATIONAL NUCLEAR SAFETY ADVISORY GROUP, Management of Operational Safety in Nuclear Power Plants, INSAG-13, IAEA, Vienna (1999).

[10] INTERNATIONAL NUCLEAR SAFETY ADVISORY GROUP, Safety Management of Operating Lifetimes of Nuclear Power Plants, INSAG-14, IAEA, Vienna (1999).

[11] INTERNATIONAL NUCLEAR SAFETY ADVISORY GROUP, Key Practices in Strengthening Safety Culture, INSAG-15, IAEA, Vienna (2002).

[12] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety Culture in the Maintenance of Nuclear Power Plants, Safety Reports Series No. 42, IAEA, Vienna (2005).

[13] INTERNATIONAL ATOMIC ENERGY AGENCY, Safe Long Term Operation of Nuclear Power Plants, Safety Reports Series No. 57, IAEA, Vienna (2008).

[14] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety of Nuclear Power Plants: Design, IAEA Safety Standards Series No. NS-R-1, IAEA, Vienna (2000).

[15] INTERNATIONAL ATOMIC ENERGY AGENCY, Evaluation of the Safety of Operating Nuclear Power Plants Built to Earlier Standards, A Common Basis for Judgement, Safety Reports Series No. 12, IAEA, Vienna (1998).

Annex I

EXAMPLE OF MAPPING ALTERNATIVE PSR STRUCTURE TO SAFETY FACTORS

As explained earlier it is reasonable to check compliance with the issues covered by the safety factor approach when using another PSR structure. One example of such mapping is provided in the following table. It has been used by British Energy Generation Ltd for the first PSRs of their Advanced Gas Cooled Reactors. For each of these topics a separate report has been prepared. At the end of the review the key issues from all the topics have been collected in a summary report.

Note, in this example of PSR, emergency planning and beyond design basis analysis were justified as exclusions from the PSR because they were reviewed elsewhere under different programmes.

These exclusions were identified and justified when defining the scope of PSR at the start of the programme. However, these missing aspects were taken into account for the overall picture of the plant safety status.

TABLE SHOWING MAPPING OF SAFETY FACTORS

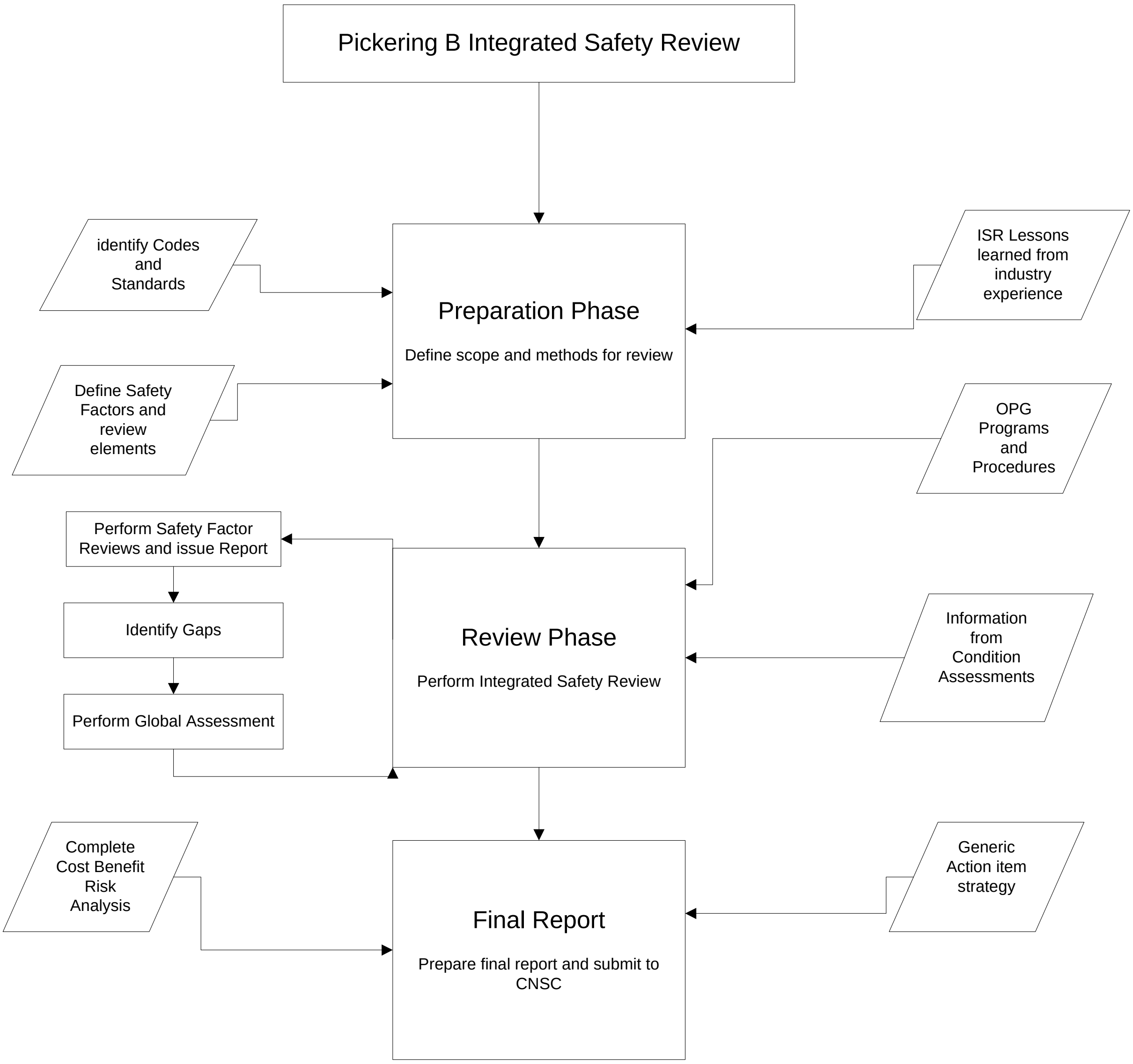
Topic no.	Topic Title	Relevant IAEA safety factors
1.1	Fire	3,5,6,7
1.2	Steam, Hot& Cold Gas Release	3,5,6,7
1.3	Missiles	3,5,6,7
1.4	Dropped Loads & lifting equipment	3,5,6,7
1.5	Local Flooding	3,5,6,7
1.6	Gas Cloud Release	3,5,6,7
1.7	Vehicular Transport	3,5,6,7
2.1	Seismic	3,5,6,7
2.2	Wind Loading	3,5,6,7
2.3	External Flooding	3,5,6,7
2.4	Aircraft Impact	3,5,6,7
2.5	Industrial Hazards	3,5,6,7
2.6	Extreme Ambient Temperatures	3,5,6,7
3.1	Review of Operation	8,9
3.2	Review of Safety Management	10,12
3.3	Radiation Monitoring and Protection	8,14
4.1	Fuel Handling	2,3,4,12
4.2	Core	2,3,4
4.3	Control Rods	2,3,4
4.4	Diverse Shutdown Systems	2,3,4
4.5	Gas Baffle	2,3,4

4.7	Core Retraint	2,3,4
4.8	Guide Tubes/Charge Tubes	2,3,4
4.9	Boilers	2,3,4
4.10	Gas Circulators	2,3,4
4.11	Pre-stressed Concrete Pressure Vessel	2,3,4
4.12	PCPV Liner & Insulation	2,3,4
4.13	Thermal Coolant	2,3,4
4.14	Primary Coolant	2,3,4
4.15	Secondary coolant	2,3,4
4.16	CW Systems	2,3,4
4.17	Reactor Safety Circuits	2,3,4
4.18	Control & Instrumentation	2,3,4
4.19	Radioactive Waste Handling	2,3,4,8,14
4.20	Steam Pipe work	2,3,4
4.21	Electrical Supplies	2,3,4
4.22	H&V	2,3,4
4.23	Post Trip Sequencing Equipment	2,3,4
5.1	PSA & HFA	5,6,7,11,12
5.2	Transient Analysis	5,6,7
5.3	Radiological consequences	5,6,7,14
5.4	Shutdown Safety	5,6,7,11,12
6.0	Summary Report	1-14

Annex II

EXAMPLE OF A FLOW CHART FOR THE PREPARATION OF A PSR

The Canadian nuclear power plant Pickering B has elaborated for their integrated safety review a flow chart describing the process of their activities from defining the scope and methods for the review to the preparation of the final report, to be submitted to the regulator.



Annex III

EXPERIENCES OF MEMBER STATES IN PERFORMING PSR

III-1 PERFORMANCE AND CONTENTS OF A PSR IN GERMANY

1. Objectives of a PSR and guidance on performing PSR in Germany

The following objectives of a PSR of nuclear power plants have been determined:

- Response to the question of whether the plant under consideration has a sufficient safety standard, also in its future operation,
- Assess the safety of a plant on the basis of the current plant condition and on the advances in science and technology,
- Weighting deviations from requirements according to the relevant level of defence in depth,
- Taking into account back fittings that are in the process of being implemented; especially for the beyond-design basis area,
- Assessment of the balance of the design through a probabilistic safety analysis with up-to-date methods.

The PSR supplements the permanent monitoring of nuclear power plants within the framework of state oversight. Where necessary, individual aspects of the PSR are to be continued with in-depth investigations to avoid going beyond the scope of the framework given for a PSR.

For performance and contents of a PSR in Germany, guidelines [III-1, III-2] and supplementing technical documents [III-3– III-5] have been issued in 1997. For PSA, now a revised guideline [III-6] and technical documents [III-7–III-8] are available with broadening the application area to external hazards and a level 2 PSA for full power operation. The hierarchy of the German PSR documents are shown in the Fig. III-1 below.

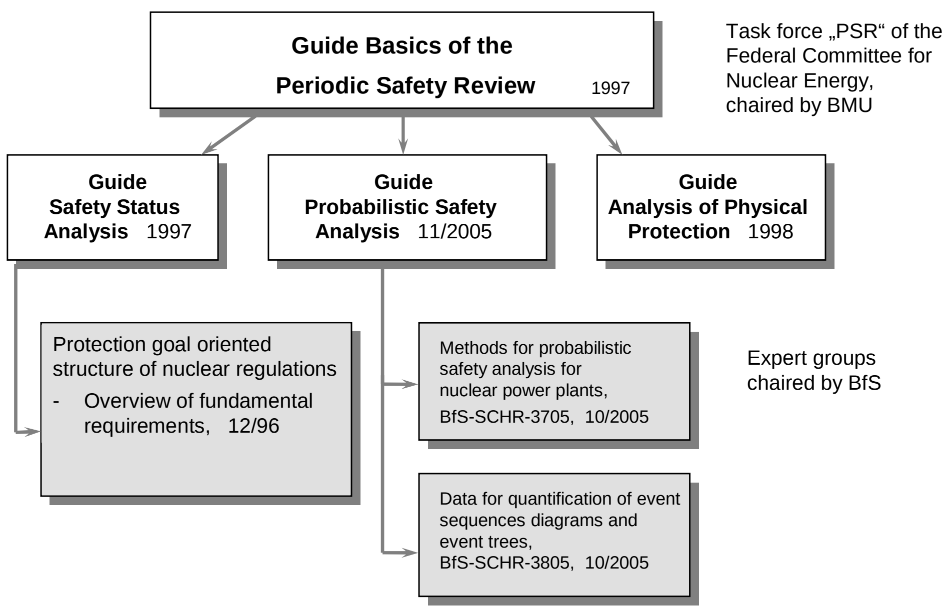


FIG III-1. Hierarchy of German PSR documents

Due to the permanent regulatory oversight of specified normal operation (levels 1 and 2), it is entirely sufficient assess the PSR results for these two levels in a simplified way. By assessing operating experience, including safety-relevant areas of operating management, the aim is to show to what extent the requirements placed on these levels are satisfied and how the technical installations and measures have proven their worth during operation thus far. Investigations concerning level 3 incidents constitute the central point of the PSR, i. e. focusing on whether the enveloping incidents can be controlled by available precautionary measures with sufficient effectiveness and reliability. The review of safety installations is to be based on valid documents and verifications. When assessing deviations from the safety goal oriented requirements, the weighting in particular is to be performed by taking the relevant level of defence in depth into account.

The licensees have to take the following steps to prepare the PSR:

1. Brief plant description
2. Safety status analysis (SSA)
3. Probabilistic safety analysis (PSA)
4. Analysis on physical protection
5. Assessment of results.

2. Brief plant description

The brief plant description intends to provide a concise overview of the plant's safety concept. At its core is an answer to the question of whether the existing verifications are sufficiently corroborated. The following aspects are to be taken into account in the description of the plant and all essential safety-related structures, systems and components:

- Configuration,
- Arrangement,
- Safety-related function,
- Design data,
- Significant safety-related modifications since commissioning or since the last PSR.

More detailed system descriptions are only necessary in the brief plant description in case there have been any essential modifications. Additionally, the plant-internal accident management measures that are assigned according to the safety goals described in the next section should be described.

Moreover, the brief plant description may include back fitting measures that have not yet been implemented or plant-internal accident management measures that have been approved or are undergoing approval and are available for inspection.

3. Safety status analysis

The safety status analysis is a deterministic analysis. It is based on operating experience and proof-of-service and essentially covers levels 1, 2 and 3 of the defence in depth safety concept.

The fundamental safety-related requirements that represent a sufficient standard of safety of the operated Nuclear power plants are oriented towards the following safety goals:

- Control and limitation of reactivity
- Limitation of radiation exposure
- Cooling of fuel elements
- Confinement of radioactive material.

The analysis addresses the question of whether the safety-goal oriented requirements have been satisfied. This is the case whenever the mentioned safety goals are achieved at any time during the representative incidents. The main emphasis is put on the safety-related parts of the plant, in particular on the behaviour of systems and components in case of internal events.

In addition, the measures stated in the plant's (severe) accident management manual are to be presented in a separate chapter. The implemented on-site accident management measures are to be presented with reference to the beyond-design-basis plant conditions stipulated in the regulatory guide on safety status analysis.

The description of operational management and evaluation of operating experience is seen as an additional essential part of the safety status analysis. Main subjects are: technical knowledge and operational organization, periodic testing and in-service inspections, maintenance, experience feedback, radiation protection and emergency preparedness. The evaluation of operating experience is to concentrate on safety aspects of normal operation, anticipated operational occurrences and incidents to be considered. The results are to be judged with regard to operating experience important to safety of plant equipment. Assessment of the results is to demonstrate whether the systems engineering requirements stated for levels 1 and 2 of the safety concept are met, and whether reliable operation with regard to accident prevention is ensured and can also be expected for the future.

4. Probabilistic safety analysis

Concerning PSA initially only the power operating mode was considered. Already at that time, it pointed out the necessity of considering start-up and shutdown conditions insofar as they can be expected to make an essential contribution to the overall plant risk.

After the PSA guideline [6] was revised, the scope of operating conditions was extended to include shutdown operation, internal flooding, fire and, to the extent that significant contributions resulted, also external impacts, particularly airplane crash, floods, explosion shockwaves and earthquakes.

In the PSA, appraisals of planned and trained-for plant-internal accident management measures can also be taken into account.

The PSA is to be performed with proven methods and realistic data giving consideration to the PSA-guideline. Plant-internal and external incidents and damages to components and plant parts are to be considered if safety functions are actuated for their control. Older plants may require a determination of the frequency of occurrence of rare external impacts caused by civilization-induced factors.

The operating experience of the individual nuclear power plants is to be acknowledged as far as possible by using plant and component specific data.

The results of the PSA should supplement the deterministic assessment of the plant safety status and its operating safety as well as being used to establish the necessity and urgency of safety improvements.

5. Assessment of results

The following points should be addressed when assessing plant safety:

- Operating experiences and proof-of-service,
- Agreement with requirements that are in line with the current state of safety technology,
- Balance of the safety concept regarding the contributions made by initiating events on the overall frequency of hazard states,

- Identification of possible safety deficits and assessment of their significance for plant safety,
- Consideration of plant-internal accident management measures,
- If required, suggestions for safety-increasing measures.

The individual assessments should be integrated into a coherent overall picture. A high and balanced safety level of the plant is given if

- The deterministic safety status analysis shows that the requirements needed to satisfy the safety goals have been met and
- The PSA demonstrates the balance of the safety concept.

The global assessment as applied in the German approach is summarized in Fig. III-2 .

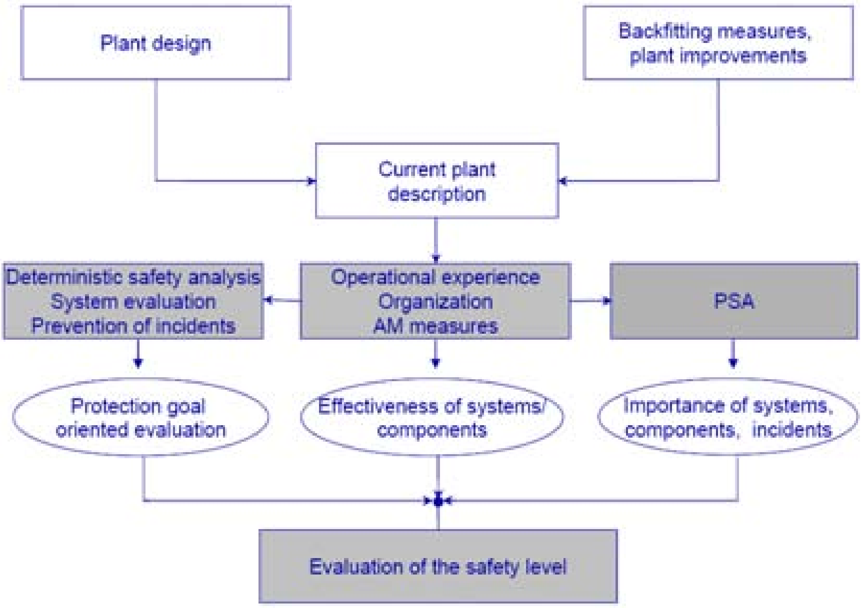


FIG. III-2. Global assessment as applied in the German approach.

III. 2 PERFORMANCE AND CONTENTS OF THE BRITISH ENERGY APPROACH TO PSR

1. Introduction

British Energy (BE) operates seven Advanced Gas Cooled Reactor (AGR) nuclear power plants in the United Kingdom, in addition to the Pressurised Water Reactor (PWR) nuclear power plant at Sizewell and the coal-fired plant at Eggborough.

During the early 1990s, the UK regulator, Her Majesty's Nuclear Installations Inspectorate (HMNII), introduced Nuclear Site Licence Condition 15 (LC 15) which requires commercial nuclear power plant operators in the United Kingdom to perform a comprehensive, systematic periodic review and reassessment of the safety cases (i.e. FSARs) for each of their nuclear power plants. Under the arrangements agreed for implementing LC 15 these reviews are conducted every 10 years. The first Periodic Safety Reviews (PSRs) for the AGRs were submitted to HMNII between 1995 and 1999. Regulatory acceptance of these reviews followed 12 to 18 months after each submission. The assessment of the second PSR (PSR2) is due to be completed by HMNII 10 years after the first PSR, and this commenced in early 2007 with the acceptance of the Hunterston B and Hinkley Point B Reviews, to be followed by the other nuclear power plants according to the programme dates summarised in Table III-1.

The purpose of the PSR is to review all aspects of nuclear safety on British Energy's nuclear power plants, with particular emphasis on the following:

- To review the period of past operation, either since commencing operation, or since the previous PSR as applicable. The objective is to demonstrate that the plant has been operated safely, within its design envelope, and that appropriate measures have been taken in response to local plant, generic fleet, national and international nuclear operational experience feedback, in order to identify and evaluate factors that could limit safe operation during the 10 year period until the next review.
- To compare the plant against the requirements of current safety assessment standards, assessment methodologies and system/component design codes, and thereby to identify any reasonably practicable enhancements to plant or procedures in order to minimize risk.
- To review ageing and degradation mechanisms of systems, structures and components (SSCs) essential to nuclear safety to confirm that the plant is safe to operate during the 10 year period until the next review, subject to continuing routine SSC's maintenance and inspections.
- To review the plant safety management performance in order to demonstrate the existence of a continuously improving, progressive and challenging environment with respect to the establishment and maintenance of a strong safety culture in all aspects of plant operation.

The overall aim of the review is to underwrite safe operation of the plant for the next 10 years, i.e. until the next PSR is due for completion.

This document describes the British Energy approach to conducting the second programme of Periodic Safety Reviews (PSR2) for their AGRs, and covers: the UK regulatory regime applicable to PSR; the review standards and methodologies applied; a typical nuclear power plant review programme and activities; the project management arrangements and responsibilities and an outline of the regulator's assessment process.

2. UK Regulatory Regime

The UK regulatory regime is essentially one of a high level goal setting and oversight approach by the regulator and, within this framework, a complementary 'self regulating' approach by the operator. In-keeping with this regime, for PSR it is the responsibility of the operator to define the scope of the review, including definition of SSCs to be covered by the review, the review standards to be adopted and also to define and justify any exclusions from the review. The scope is presented to the regulator for comment prior to commencement of the review. This 'self regulating' approach extends also to the identification of shortfalls by the PSR and the definition of the corrective actions to address them. It is very much the operator's responsibility to liquidate the corrective action programme without any prior agreement of the regulator, although, as noted later, the regulator will also identify findings as part of their Regulatory Review of each nuclear power plant's PSR. It should also be noted that the UK regulatory body have prepared their own technical guidance document for their assessment of the PSR. There is regular formal and informal communication between the operator and regulator at all stages of the review, including during the corrective action programme.

TABLE III-1: BRITISH ENERGY STATION COMMISSIONING AND PSR ACCEPTANCE DATES

Station	Commissioning Date	Date of First PSR	Date of Second PSR
Hinkley Point B	1976	Dec 1996	Jan 2007
Hunterston B	1976	Dec 1996	Jan 2007
Dungeness B	1982-85	Jan 1998	Jan 2008
Hartlepool	1984	Jan 1999	Jan 2009
Heysham 1	1984	Jan 1999	Jan 2009
Heysham 2	1988	July 2000	Jan 2010
Torness	1988	July 2000	Jan 2010

3. Review standards and methodologies

The principles and standards used in a British Energy PSR operate at a number of different levels and these are discussed below.

Nuclear Safety Assessment Principles

New nuclear safety principles (NSPs) were developed before commencing the PSR1 programme, specifically designed for the safety assessment of older plants. In developing these safety principles it was recognised that it would be impracticable to back-fit in full for the older plants to meet the very latest standards. These principles were therefore based on an ALARP (as low as reasonably practicable) approach which specified a minimum (tolerable) level risk target with the additional requirement to further reduce the level of risk as far as reasonably practicable. These NSPs included the following:

- Deterministic Principles - defining the levels of reactor fault protection required, depending on fault frequency, in terms of number of lines of protection and the levels of plant redundancy and diversity.
- Probabilistic Principles - defining risk criteria commensurate with the risk acceptance levels defined by the Government's Health and Safety Executive in their document on the Tolerability of Risk from Nuclear Power Stations (TOR, [III-9]).
- New criteria for assessment against the threat from hazards such as seismic, high winds, site flooding and fire.

As a result of the requirement to assess against probabilistic principles, whole reactor plant model, level 2 Probabilistic Safety Analyses (PSAs) were performed for the first time during PSR1 for all except the newest AGRs, for which the original design basis included a probabilistic element.

For the AGR PSR2 programme, these NSPs were reviewed, updated where appropriate and re-issued to take account of developments over the past 10 years and these are defined in 'Nuclear Safety Principles for the Safety Review of the Gas Cooled Reactors' [III-10].

IAEA Standards

At all levels compliance was sought with IAEA standards, most notably 'IAEA Safety Guide, NS-G-2.10, Periodic Safety Review of Nuclear Power Plants' [III-11]. This safety guide was issued following the first PSR programme and British Energy was a contributor to this guide. As a precursor to the overall PSR2 programme, British Energy reviewed its PSR arrangements to show compatibility with [III-11]. In addition, reviewers were asked to consider IAEA guidelines applicable to their specific areas.

Other Standards

A large number of lower level standards are also needed to complete the PSR. These standards cover the engineering and technical aspects of the plant design and assessment. For the PSR2 programme the most up-to-date standards were systematically drawn together from British and international standards and compared with those last used in PSR1. These standards are too numerous to list here, but were reviewed and drawn together in documents called Discipline Based Reviews (see Table III-2). This was done as part of the PSR2 process that is outlined below in Section 4. The Discipline Based Reviews for the first nuclear power plant in the current (PSR2) programme were submitted to HMNII before review work commenced and these covered the Nuclear Safety Principles as well as lower level standards.

TABLE III-2 – DISCIPLINE BASED REVIEWS OF PRINCIPLES, STANDARDS, CODES & METHODOLOGIES

Number	Title	Description
DR1	Nuclear Safety Principles for the Safety Review of the Gas Cooled Reactors	Review of the requirements set out in Nuclear Safety Principles for the Safety Review of the Gas Cooled Reactors against current standards.
DR2	Structural integrity	Review of the Company requirements and guidance on standards and methodologies against current standards and developments in the technical area.
DR3	Fuel handling	
DR4	Radioactive waste management developments	
DR5	Mechanical plant developments	
DR6	Electrical plant developments	
DR7	Computing and C&I systems developments	
DR8	Civil works	

4. Timetable and activities for PSR

Figure III-3 shows the timetable for a typical second PSR of an AGR nuclear power plant. The steps/activities shown in Figure III-3 are described below. In order to ensure compliance with the project intentions and consistency of approach by the many contributors to each nuclear power plant's PSR2, procedures were developed to cover each of the main activities.

Specifications

For each of the review areas in Table III-3, a Periodic Safety Review Specification (PSRS) is produced and all of these specifications are included in a Station Specific Scope Document. Notably, these PSRS documents identify:

- The area of plant to be reviewed or the safety issue to be addressed, including detailed plant components/systems
- Specific exclusions (see Table III-4)
- Interfaces with other topics
- The standards and benchmarks to be used

These specifications, produced with the support of BE's Suitably Qualified and Experienced Persons (SQEP), provide the means of ensuring that the Review Areas are covered appropriately and serve to identify the boundaries between review areas.

In order to ensure that key stakeholders in the safety review process are kept informed, the scope document for each nuclear power plant's PSR, which includes the specifications, is passed to HMNII before review work commenced.

The PSR document structure of Table III-3 has been deliberately chosen to reflect the structure of the current safety case documentation for an AGR nuclear power plant and therefore differs from the 'safety factor' structure/approach of the IAEA guide NS-G-2.10 [III-11]. In order to confirm that BE's chosen PSR2 documentation structure ensures comprehensive scope coverage consistent with that of [III-11], a mapping exercise was carried out and this was subsequently reported to the regulator.

TABLE III-3: PSR 2 DOCUMENTATION AND WORK BREAKDOWN STRUCTURE

TITLE	**Review Areas & Supporting Documents**
CHAPTER 1 **Adequacy of Nuclear Safety Case Statement**	Chapters 2, 3, 4 & 5
CHAPTER 2 **Operations & Safety Performance**	R2.01 Review of Operation
	R2.02 Safety Management Systems
	R2.03 Radiological Protection and Monitoring
	R2.04 Emergency Planning Arrangements
CHAPTER 3 **Systems, Structures & Components**	R3.01 Fuel Handling
	R3.02 Core Systems
	R3.03 Control Rods
	R3.04 Secondary Shutdown System
	R3.05 Hot Box Dome Structure
	R3.06 Core Support Structure
	R3.07 Core Restraint
	R3.08 Guide Tubes
	R3.09 Boilers
	R3.10 Gas Circulators
	R3.11 Prestressed Concrete Pressure Vessel
	R3.12 PCPV Penetrations and Liner
	R3.13 Pressure Vessel Thermal Shield
	R3.14 Primary Coolant System
	R3.15 Secondary Coolant Systems
	R3.16 Main Cooling Water and Auxiliary Systems
	R3.17 Reactor Safety Circuits
	R3.18 Control and Instrumentation Equipment
	R3.19 Radioactive Waste Handling
	R3.20 Steam Pipework
	R3.21 Electrical Supplies
	R3.22 Heating & Ventilation Systems
	R3.23 Reactor Shutdown Sequencing Equipment
	R3.24 Civil Structures
CHAPTER 4 **Safety Analysis**	R4.01 Fault Based Safety Assessment
	R4.02 Transient Analysis
	R4.03 Radiological Consequences
	R4.04 Shutdown Safety Case
	R4.05 Originally used for Hazards – now covered in Chapter 5
	R4.06 PSA
	R4.07 SBERGs
	R4.08 Worker Risk
CHAPTER 5 **Internal & External Hazards**	R5.01 Fire
	R5.02 Steam Release
	R5.03 Hot Gas Release
	R5.04 Cold Gas Release
	R5.05 Missile Impact
	R5.06 Dropped Loads and Lifting Equipment
	R5.07 Internal Flooding and Corrosive Fluid Release
	R5.08 Internal Toxic Gas Cloud
	R5.09 Vehicular Impact
	R5.10 Seismic
	R5.11 Wind Loading
	R5.12 External Flooding
	R5.13 Aircraft Impact
	R5.14 Industrial Hazards
	R5.15 Extreme Ambient Temperatures
	R5.16 Electro-Magnetic Interference
	R5.17 Lightning
	R5.18 Drought and Biological Fouling

TABLE III-4: AREAS EXCLUDED FROM THE PERIODIC SAFETY REVIEW 2

Topic or Plant Area	**Basis**
Main turbine, generator & condenser systems	The nuclear safety aspects are covered under relevant areas of review eg. missiles hazard.
Decommissioning arrangements	Covered by LC35 and 5-yearly review
Sabotage	
Ex-reactor criticality assessments	Covered by LC4
Off-site handling and safety case for fuel flasks	Covered by transport Regulations and LC5

Discipline Reviews

During the first PSR it was noted that individual reports frequently referred to similar aspects of a standard or methodology. In essence each topic had to work out for itself which standards were most appropriate and how they should be applied. This led to duplication of effort and also raised issues of consistency. To avoid these problems, PSR2 introduced the concept of Discipline Based Reviews. This meant that before the review phases began, information on standards and their applicability was gathered together in a small number of reports. These are listed in Table III-2. The principal role of these reports is to identify and compare the current modern standards with the standards used in design and installation (and in the first PSR). This process therefore simplified the work of those undertaking the review.

Preliminary Reviews

These are undertaken of each area once the review standards have been defined by means of the Discipline Based Reviews. The primary objective is to identify any significant issues requiring prompt attention and which may require a long lead time to address them. To fit this purpose Preliminary Reviews are high-level assessments based on balanced engineering judgement. The primary tools in achieving this Preliminary Review are meetings between the Author (the reviewer), nuclear power plant System Engineers and other specialist parties. In addition to this, the Author has the benefit of access to the appropriate Discipline Based Reviews giving insights into changes in standards and also to Safety System Reviews. These Safety System Reviews are interim performance reviews of some of the plant systems, conducted at set intervals (typically 3 yearly) under the auspices of nuclear power plant staff. The primary outputs from this process are the Preliminary Review Report containing a list of nuclear safety shortfalls, categorized according to their nuclear safety significance, and the early commencement of a corrective action work programme to address the more complex and/or long lead-time issues.

Main Reviews

Following the Preliminary Review, each review area is subjected to a Main Review. This is a comprehensive review to the full requirements of the PSRS. This Main Review also offers the opportunity to consider further those issues highlighted in the Preliminary Review. The ~50 review areas present a wide range of diversity, both technically and in terms of scale. Because of this they are completed to different timescales by reviewers from a wide range of specialist discipline areas. The scope of the Main Reviews includes consideration of historical plant data to a prescribed cut-off date (typically just prior to the start date of the Main Review phase) and also consideration of significant changes to the plant or its safety documentation which are in progress at the time of the review. On completion, the Main Reviews are subject to verification to British Energy's quality assurance standards. In terms of the process, the outcome is a Main Review report for each of the areas listed in Table 3. Each of these reports includes a list of nuclear safety shortfalls. These shortfalls are categorized according to their nuclear safety significance.

Summary Chapters

As shown in Table III-3, the PSR work is grouped under five headings that translate into five chapters. The production of the Chapters is the final phase of the review part of the project. This involves the collation of the information in the Main Reviews into a summary format. It also offers the opportunity to draw conclusions across each Chapter area. The five Chapters comprise the following:

- Chapter 1 – 'Adequacy of Nuclear Safety Case Statement' - this is the summary of the whole review and draws on the conclusions of the other chapters described below. Chapter 1 covers the background of the review, outlines the review process adopted, explains the outcome of the review, and shows how the satisfactory outcome assures safe operation of the plant until the next PSR is due for completion in 10 years time.
- Chapter 2 – 'Review of Operations and Safety Performance' - covers the review of the operating history of the plant, including consideration of plant data, system unavailability, radiological protection, safety management systems, and emergency preparedness.
- Chapter 3 – 'Review of Systems, Structures and Components' - reviews safety critical plant systems and structures of the nuclear power plant and considers plant performance, ageing and obsolescence issues, and compliance with modern standards.
- Chapter 4 – 'Review of Safety Analysis' - considers the safety case analysis that underpins the safe operation of the plant. It reviews the analysis of potential plant faults. It considers probabilistic safety analysis, Transient Analysis, and an ALARP analysis. This chapter also considers faults and hazards for the shutdown reactor, as well as including hazards in the probabilistic and ALARP analyses of hazards for the reactors at power.
- Chapter 5 - Internal & External Hazards - considers the hazards safety case that underpins the safe operation of the plant. It reviews the analysis of the impact of and protection against internal and external hazards, with the probabilistic and ALARP aspects covered in Chapter 4.

Consolidation

Each nuclear power plant's PSR is a comprehensive major project involving several review phases, many authors and extending over several years. Also, as the reviews are produced over differing timescales, only at the end of the review does a complete picture become available and only at the end can comparisons across areas be properly drawn. Because of this complexity, the PSR process includes a consolidation phase. For each nuclear power plant's PSR the primary objective of the process is to achieve consistency and completeness across the ~50 review areas. The aims of the consolidation process are as follows:

- Ensure that issues raised in one review area are appropriately reflected in other affected review areas
- Ensure consistency in the treatment of similar issues

- Minimize overlaps and gaps
- Ensure that the outcome of the reviews properly reflects the safety significance of the issues identified

To achieve these aims, a specific team is established that is independent of the authors. The process they follow is enacted across Main Reviews within a given chapter to ensure consistency within the chapter and across all of the chapters to ensure overall consistency. Using the team approach for consolidation also allows QA checks, for example, to confirm that the full scope defined in the PSRS has been covered by the review.

Consolidation team members are allocated to deal with specific Chapters, and in the case of larger work areas, such as Chapter 3, the work is further split up between several Consolidation Team members. When the team members have reviewed the Main Reviews in their area they then undertake a further process of exchanging information with Consolidation Team members covering other reviews/chapters. When the process is completed the Main Reviews and Chapter Reports are revised and issued. This activity provides the author with the opportunity to include comment on significant events or nuclear power plant changes occurring since the review was carried out. The remainder of the historical operational data is not updated at this time.

Global Assessment

The IAEA standard for Periodic Safety Review [3] calls for a global assessment on completion of the PSR. The IAEA standard states:

“The objective of the global assessment is to present an assessment of plant safety that takes into account all unresolved shortcomings, all corrective actions and/or safety improvements and the plant strengths identified in the review of all PSR safety factors.”

The production of Chapter 1 via the summary Chapters 2 to 5, combined with the consolidation process, satisfies this guidance, by drawing together all aspects of the review and comprehensively identifying shortfalls and strengths. It covers the extent to which defence in depth is satisfied by deterministic principles and goes further in drawing together a ‘global risk judgment’ via British Energy’s ALARP process. The steps taken to ensure the alignment of the PSR process with IAEA safety factors are as follows:

1. In striving to produce a balanced overview, Chapter 1 is prepared by an author with senior nuclear plant management experience and wide ranging safety case experience.
2. All Chapters are reviewed and verified by experienced staff within British Energy’s Design Authority.
3. All the Chapters are independently reviewed and considered in totality by British Energy’s Safety and Regulation Division (BE’s ‘internal regulator’).
4. Before the submission of Chapter 1 to the regulator, Chapter 1 is further presented for review by the Nuclear Safety Committee, an independent panel representing senior level Nuclear Safety experience from across the UK Nuclear industry.

The global assessment is reported in Chapter 1. The global assessment includes a summary of British Energy’s comprehensive suite of nuclear safety management processes which ensure that risks are maintained As Low As Reasonably Practicable (ALARP) during the period of operation following on from the PSR, up to the time of completion of the next PSR.

Independent Periodic Review Assessment

PSR2 includes an Independent Periodic Review Assessment (IPRA) of PSR review documents by British Energy's 'internal regulator', the Safety and Regulation Division. This IPRA is applied to every Main Review report, each Chapter, and considers the shortfalls/corrective actions raised by the PSR.

Corrective Actions

As part of the PSR process, the management of the corrective action programme to address the resolution of the nuclear safety shortfalls of high and medium significance identified by the PSR is managed by the centrally based Periodic Safety Review Project Team (see Section 5 below). However, it should be noted that, from experience to date, typically, 25%-30% of the more significant PSR2 corrective actions are discharged by nuclear power plant staff, with the remainder being discharged under the auspices of the BE central technical support functions The management of the PSR corrective actions is covered by a formal PSR Project Procedure. In summary this process requires a Shortfall Solution Proposal outlining the work required to address the shortfall. The work will then be undertaken via the Company's existing work control and quality arrangements. Completion of the shortfall will be agreed via a closure process that requires agreement of the BE technical SQEP, the PSR Team, SRD and the nuclear power plant management. The objective is to complete the corrective action programme for high and medium significance shortfalls by the Regulator's 'Decision' date (i.e. within one year of submitting the full review for regulatory assessment), a regulatory requirement. It is this short timescale for completing the more significant corrective actions that necessitated the introduction of the early Preliminary Review to identify potentially complex or long lead time significant issues.

A programme is developed to ensure that corrective actions to address the shortfalls are implemented in a timely manner. BE's policy does allow shortfalls designated as being of 'Low' safety significance to be given lower priority, but all are targeted for completion within a 2 year period of the Regulator's 'Decision' date unless there are compelling arguments for longer implementation periods. The responsibility for final acceptance of closure of 'Low' issues lies with the nuclear power plant management.

Further to this a number of Lifetime Management Issues (LMIs) are identified. These relate to issues such as SSC refurbishment in which there is no current safety risk, but where obsolescence or ageing and degradation may lead to non-compliance with the safety case during the next PSR period. In general, these are not considered to be a PSR shortfall and they are be managed by the nuclear power plant as part of their normal ongoing plant reliability processes.

5. Project management and organization

In order to ensure consistency of approach to the PSR process across the seven AGR nuclear power plants, and in recognition of the fact that most of the review documentation is produced by or under the auspices of the BE central technical support functions, the decision was taken to place responsibility for the overall project management of the PSR programme under a dedicated PSR Group established within the company's Design Authority (the central technical support function responsible for Safety Case Management). Irrespective of this delegation of authority, each nuclear power plant still retains overall responsibility for its PSR. Figure III-4 shows the key stakeholders, including contractor support, involved in the production of a PSR and indicates the lines of responsibility.

6. Regulator's assessment

On receiving each nuclear power plant's PSR (i.e. the 5 Chapter reports and ~ 50 supporting Main Review Reports) from BE, HMNII commences the regulatory assessment which takes approximately one year. During this period there is regular dialogue as the regulator's assessors raise queries/points of clarification and BE provides responses as promptly as possible in order to avoid delay in the process. When the assessment of each review area is completed, including the provision of responses to all queries raised, the regulator's assessor determines whether there are any issues for which further work is required and raises 'Findings' accordingly. Towards the end of the regulatory assessment period, the 'Findings' from all the assessors are gathered together and discussed with BE. BE then provides an Action Plan of corrective actions to address the findings, including appropriate timescales and milestones. At this stage the regulator issues its review findings and also its decision regarding the adequacy of the PSR as the basis for operation for a further ten years. This decision will be on the basis of the agreed action plan and may include additional caveats.

7. Outcome of PSR 2

The current position following submission of the Hinkley Point B, Hunterston B and Dungeness B PSR2s to HMNII may be summarized as follows:

By comparison with PSR1, with the notable exception of I&C related issues, there are very few current standards shortfalls of significance identified in PSR2. This is not surprising given the approach to full maturity of both nuclear safety and plant design standards in the past 10-15 years.

The next 10 year period of operation covered by PSR2 takes the older AGR plants beyond their original design lives and therefore, as would be expected, ageing and obsolescence issues are far more prominent in PSR2 than was the case in PSR1. Consequently the need to update safety cases to address SSC ageing/degradation for the 10 year PSR period has been identified for each nuclear power plant.

Improvements to station procedures and other safety case related documentation have been identified. Again this is not particularly surprising since Technical Specifications have been introduced to replace Operating Rules and Identified Operating Instructions during the interval between PSRs 1&2. The technical specifications, which prescribe clear plant release and availability limits were introduced as a stand-alone project. Now with the benefit of user experience, enhancements to some Technical Specifications are being identified within PSR2, often to improve their clarity and hence fitness-for-purpose.

Some requirements for further additions to the SSC's Maintenance Testing and Inspection schedule have been identified in response to changes in the significance of the claims on certain SSCs.

The updated PSAs for PSR2 show only relatively insignificant changes in overall plant risk levels compared to the PSR1 results. Again this is not surprising as all the modifications to plant that were reasonably practicable had been implemented as part of PSR1.

To date, with the exception of the requirement to update SSC ageing/degradation aspects, relatively few significant changes to safety cases (FSARs) have been identified by PSR2.

REFERENCES TO ANNEX III

[III-1] Federal Ministry of the Environment, Nature Conservation and Reactor Safety (BMU), Announcement of the Guidelines for Conducting Periodic Safety Reviews (PSR) for Nuclear Power Plants in the Federal Republic of Germany, August 18, 1997: Basics of the Periodic Safety Review, Guide on Safety Status Analysis, Guide on Probabilistic Safety Analysis, Federal Bulletin Nr. 232a from December 11, 1997

[III-2] Federal Ministry of the Environment, Nature Conservation and Reactor Safety (BMU), Announcement of the Guideline on Deterministic Analysis of Physical Protection for Conducting Periodic Safety Reviews (PSR) for Nuclear Power Plants in the Federal Republic of Germany, June 25, 1998, Federal Bulletin Nr. 153 from June 25, 1998

[III-3] Working Group on the Protection Goal Concept, Protection Goal Oriented Structure of the Nuclear Regulatory Framework – Overview of the Generic Requirements: December 1996, BfS-KT-17/97, Salzgitter 1997

[III-4] Expert Group on PSA for NPP, Methods for a Probabilistic Safety Analysis for Nuclear Power Plants, December 1996, BfS-KT-16/97, Salzgitter 1997

[III-5] Expert Group on PSA for NPP, Data for Quantification of event trees and fault trees, April 1997, BfS-KT-18/97, Salzgitter 1997

[III-6] Federal Ministry of the Environment, Nature Conservation and Reactor Safety (BMU), Announcement of the Guideline for Conducting the „Safety Review according to § 19a of the Atomic Energy Act – Guideline on PSA –“ August 30, 2005, Federal Bulletin Nr. 207a from November 3, 2005

[III-7] Expert Group on PSA for NPP, Methods for a Probabilistic Safety Analysis for Nuclear Power Plants, August 2005, BfS-SCHR-37-05, Salzgitter, October 2005

[III-8] Expert Group on PSA for NPP, Data for a Probabilistic Safety Analysis for Nuclear Power Plants, August 2005, BFS-SCHR-38-05, Salzgitter, October 2005

[III-9] The Tolerability of Risk from Nuclear Power Stations, Health and Safety Executive, HMSO Books ISBN 0 11 886368 1, 1988

[III-10] Nuclear Safety Principles for the Safety Review of the Gas Cooled Reactors, NEL/ENG/003, NS-COP-002 Appendix A, British Energy

[III-11] Periodic Safety Review of Nuclear Power plants, IAEA Safety Guide NS-G-2.10

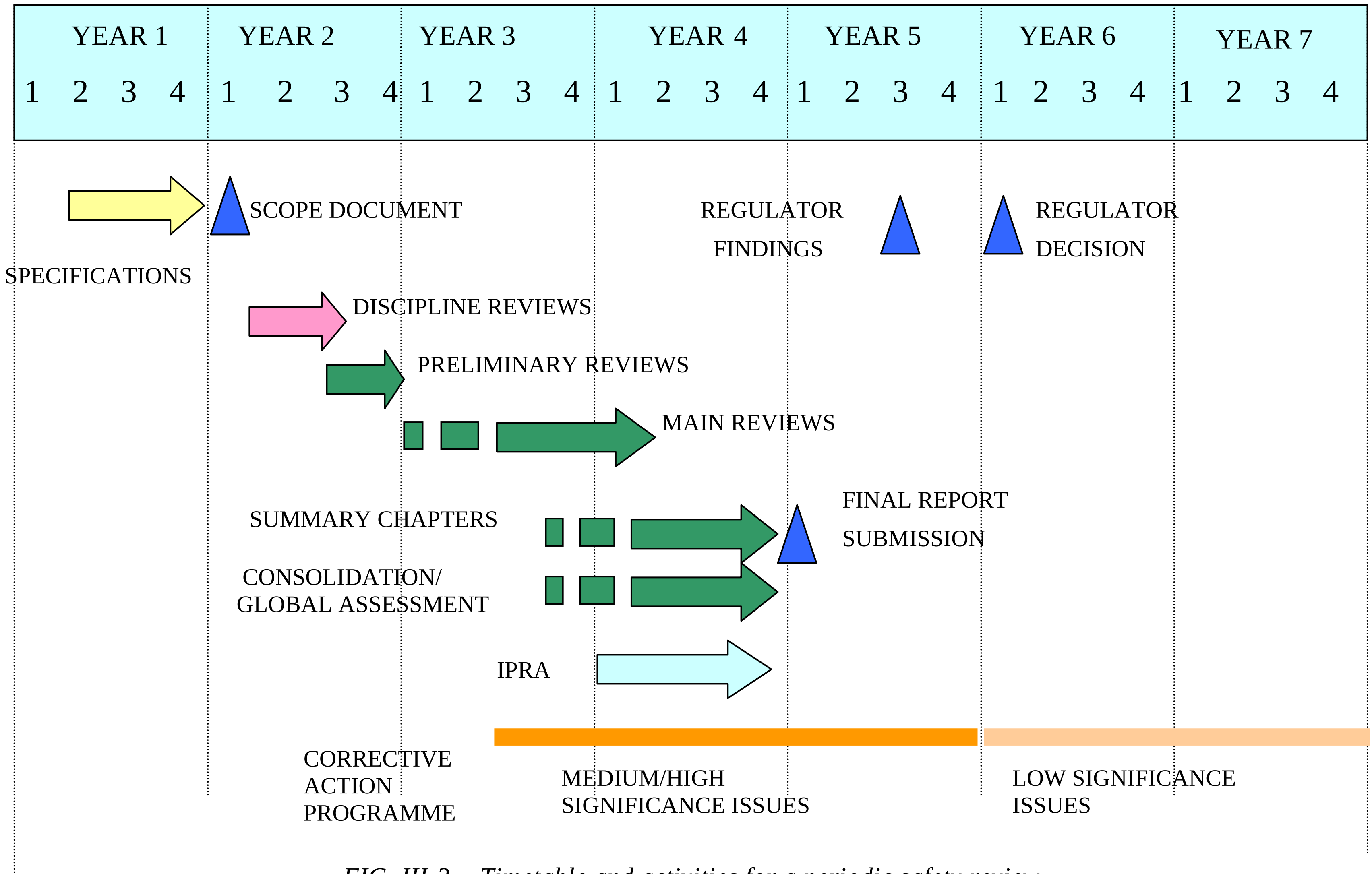


FIG. III-3. - Timetable and activities for a periodic safety review

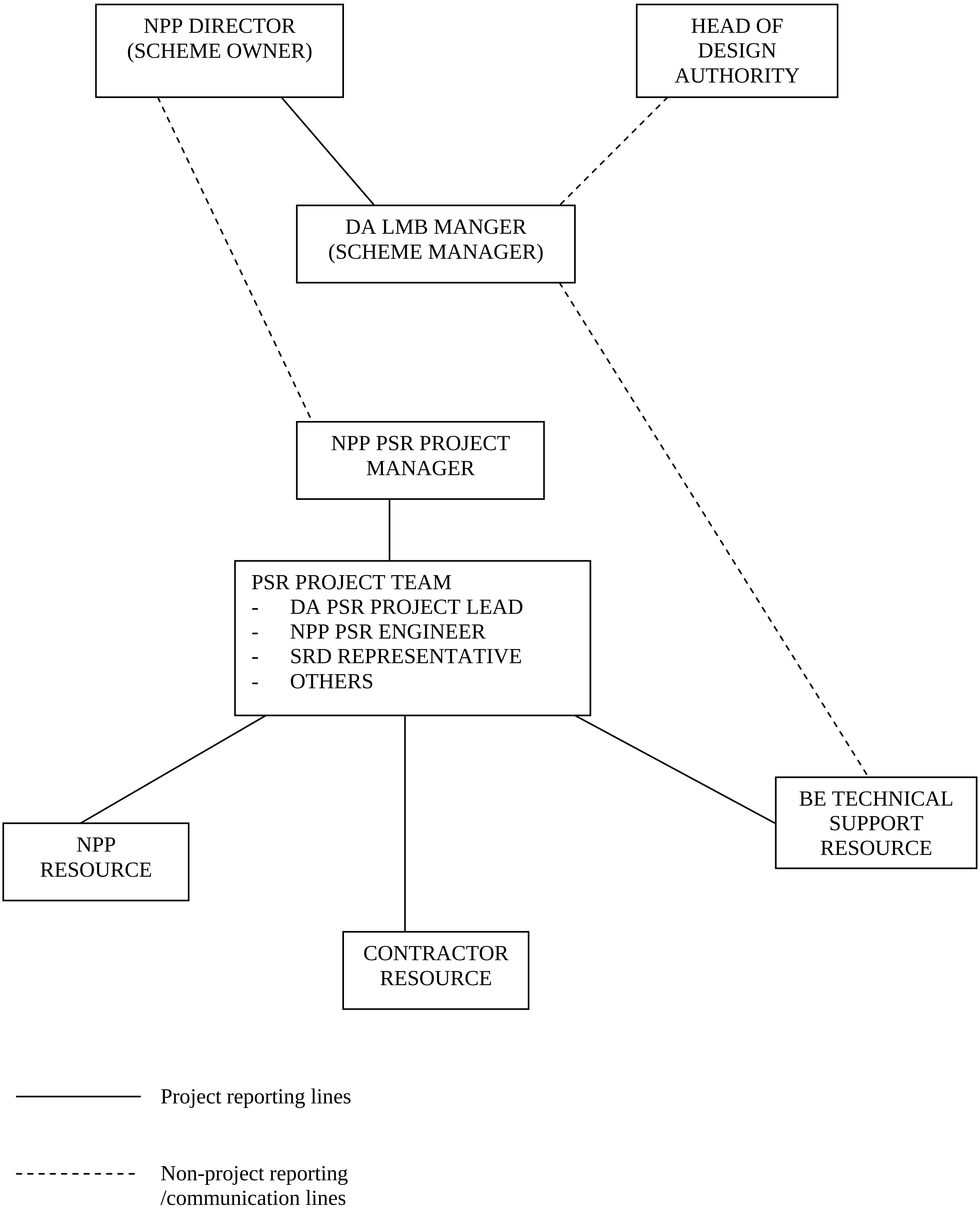


FIG. III-4 – PSR2 Project Structures

Annex IV

ALTERNATIVE APPROACH TO PSR

1. Introduction

The US regulatory approach provides a continuum of assessment and review that ensures public health and safety throughout the period of plant operation. As discussed below, plant safety is improved by a combination of the ongoing NRC regulatory process, oversight of the current licensing basis, backfitting, broad-based evaluations, license renewal, and licensee initiatives that go beyond the US regulations.

2. The NRC's Robust and Ongoing Regulatory Process and the Current Licensing Basis

Before issuing an operating license, the NRC comprehensively determines that the design, construction, and proposed operation of the nuclear power plant satisfy the NRC's requirements and reasonably ensure the adequate protection of the public health and safety. However, the licensing basis of a plant does not remain fixed for the 40-year term of the operating license. The licensing basis evolves throughout the term of the operating license because of the continuing regulatory activities of the NRC, as well as the activities of the licensee.

The NRC engages in many regulatory activities which, when considered together, constitute a process that provides ongoing assurance that the licensing bases of nuclear power plants provide an acceptable level of safety. This process includes inspections, audits, investigations, evaluations of operating experience, regulatory research, and regulatory actions to resolve identified issues. The NRC's activities may result in changes to the licensing basis for nuclear power plants through promulgation of new or revised regulations, acceptance of licensee commitments to modify nuclear power plant designs and procedures, and the issuance of orders or confirmatory action letters. The agency also publishes the results of operating experience analysis, research, or other appropriate analyses through generic communication documents such as bulletins and generic letters. Licensee commitments in response to these documents also change the plant's licensing basis. In this way, the NRC's consideration of new information provides ongoing assurance that the licensing basis for the design and operation of all nuclear power plants provides an acceptable level of safety.

In addition to NRC-required changes in the licensing basis, a licensee may also voluntarily seek changes to the current licensing basis for its plant. However, these changes are subject to the NRC's formal regulatory controls on changes (such as 10 CFR 50.54; 10 CFR 50.59; 10 CFR 50.90; and 10 CFR 50.92, "Issuance of Amendment"). These regulatory controls ensure that licensee-initiated changes to the licensing basis for a plant are documented and that the licensee obtains NRC review and approval before implementing changes, when appropriate. The licensee must report to the NRC any changes or modifications it makes to the licensing basis without prior NRC review at least every 2 years. Region-based NRC inspectors perform a sampling inspection of those changes in accordance with the Reactor Oversight Process to ensure that the licensee has properly characterized the changes or modifications.

3. The Backfitting Process: Timely Imposition of New Requirements

The NRC recognized the need to consider new requirements systematically rather than depending on the license renewal process or other regulatory processes to decide on plant upgrades. In the late 1970s and early 1980s, the NRC recognized the need for a process to determine when to address generic issues for all plants. As a result, the NRC developed the “backfitting” process.

Also known as the Backfit Rule, 10 CFR 50.109 applies to both generic and plant-specific backfits for power reactors. It defines a “backfit” as any modification of or addition to plant systems, structures, components, procedures, organizations, design approvals, or manufacturing licenses that may result from the imposition of a new or amended rule or regulatory staff position. Except in the case of backfits that are imposed to bring a licensee back into compliance with its license or to ensure adequate protection of the public health and safety or common defence and security, the rule requires a cost-benefit backfit analysis. The NRC must determine though a backfit analysis that the proposed backfit will substantially increase the overall protection of the public health and safety (or common defence and security) and that the direct and indirect costs for the facility are justified in view of the increased protection. Economic costs will not be considered in cases of ensuring, defining, or redefining adequate protection of the public health and safety, or in cases of ensuring compliance with NRC requirements or written licensee commitments.

Backfitting is expected to occur and is an inherent part of the regulatory process. However, it is permitted only after a formal, systematic review to ensure that changes are properly justified and suitably defined. The requirements of this process are intended to ensure order, discipline, and predictability and to optimize use of NRC staff and licensee resources.

4. The NRC’s Extensive Experience with Broad-Based Evaluations

In the mid-1970s, the NRC recognized the importance of assessing the adequacy of the design and operation of currently licensed nuclear power plants, understanding the safety significance of deviations from applicable current safety standards that may have been approved after those3 Standard Review Plans help ensure the quality and uniformity of staff reviews and provide a well-defined base from which to evaluate a licensee or applicant submittal. The Standard Review Plans are also intended to make information about regulatory matters widely available, to enhance communication with interested members of the public and the nuclear power industry, and to improve the understanding of the staff review process.

Consequently, in 1977, the NRC initiated the Systematic Evaluation Program (SEP). From a list of approximately 800 potential issues and topics related to nuclear safety, the SEP found that the regulatory requirements for 137 issues had changed sufficiently to warrant evaluation. The staff then compared the designs of 10 of the older plants to the licensing criteria delineated in the then recently issued Standard Review Plan. After further review, the staff determined that 27 issues required some corrective action at one or more plants and resolution of those issues could lead to safety improvements at other operating plants built at about the same time. These 27 issues became known as the 27 “SEP lessons learned.”

In 1984, NRC staff presented the 27 SEP lessons learned to the Commission as part of a proposal for an Integrated Safety Assessment Program (ISAP). The staff developed this programme to review safety issues for a specific plant in an integrated manner instead of continuing the SEP at other older operating reactors. In November 1984, the Commission published the “Commission Policy Statement on the Systematic Evaluation of Operating Nuclear Power Reactors.” In this policy statement, the Commission articulated its view that issues relating to the safety of operating nuclear power plants can be more effectively and efficiently implemented in an integrated, plant-specific review. For the first time, the Commission discussed probabilistic safety analysis as a method to obtain consistent and comparable results which could be used to enhance a safety assessment. Eventually, the ISAP program initiative was subsumed by the risk-informed approach associated with the Individual Plant Examination (IPE) programme.

In the late 1980s and throughout the 1990s, the NRC continued its efforts to strengthen its regulatory infrastructure and ensure continued safe operation of commercial nuclear power plants through inspection, broad-based assessment, and where appropriate, establishment of new generic requirements. For example, the Commission determined that licensees should assess the accessibility and adequacy of their design-basis information and determine whether their plants needed a design-basis reconstitution programme.

5. licence Renewal Confirms Safety of Plants

As late as 1991, some plants had not definitively resolved the 27 SEP lessons learned. As the staff considered a process to renew the operating licenses for the operating nuclear power plants, it assessed the best way to address these 27 issues.

Of the 27 issues, four had been completely resolved for all plants. One other issue was of such low safety significance that it required no additional action. The staff determined that none of the remaining 22 issues required immediate action to protect public health and safety. The staff placed these 22 issues into the established regulatory process for determining the safety significance of generic issues.[4]

In developing the licence renewal Rule, the Commission concluded that issues material to the renewal of a nuclear power plant operating license are limited to those issues that the Commission determines are uniquely relevant to protecting the public health and safety and preserving common defence and security during the period of extended operation. Other issues would, by definition, be relevant to the safety and security of the public during current plant operation. Given the Commission’s ongoing obligation to oversee the safety and security of operating reactors, the existing regulatory process within the present 40-year license term would address issues related to current plant operation rather than deferring the issues until the time of license renewal. Licence renewal applicants are required to complete an integrated plant assessment (IPA)[5] and evaluate time-limited aging analyses.

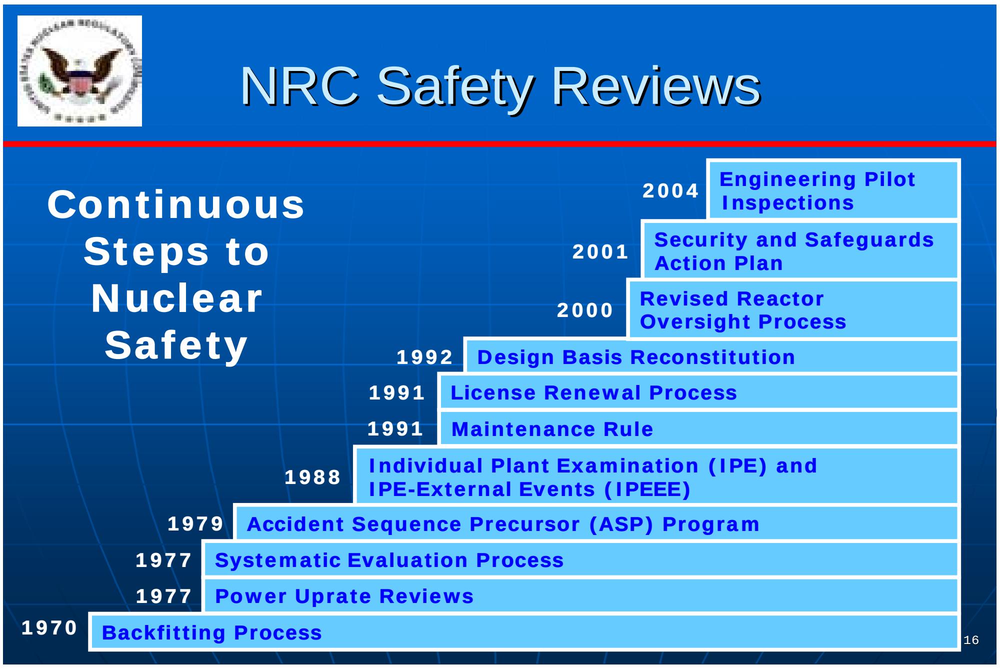
6. Risk-Informed Regulation and the Reactor Oversight Process

The NRC continues to actively increase the use of risk insights and information in its regulatory decision-making.

In 2000, the NRC implemented a revised Reactor Oversight Process using risk insights and lessons learned from more than 40 years of regulating nuclear power plants. The previous oversight process evolved during a period when the nuclear power industry was less mature and there was much less operational experience on which to base rules and regulations. Very conservative judgments governed the rules and regulations. Significant plant operating events occurred with some frequency, and the oversight process tended to be reactive and prescriptive, closely observing plant performance for adherence to the regulations and responding to operational problems as they occurred.

After nearly four decades of operational experience and generally steady improvements in plant performance, the Reactor Oversight Process now focuses more of the agency’s resources on the relatively small number of plants that evidence performance problems. The Reactor Oversight Process is more effective in correcting performance or equipment problems today because the agency’s response to problems is more timely and predictable.

The Reactor Oversight Process makes greater use of objective performance indicators. Together, the indicators and inspection findings provide the information needed to support reviews of plant performance, which are conducted quarterly. In addition, the Reactor Oversight Process features expanded semiannual reviews, which include inspection planning and a performance report (all of which are posted on the NRC's public Web site).



7. Licensee Responsibilities for Safety: Regulations and Initiatives Beyond Regulations

As in many countries, US nuclear power plant licensees are responsible for the safety of their facilities. This responsibility is embedded in their license and in the NRC's regulatory infrastructure. Under the regulatory umbrella, licensees routinely assess new technologies, offnormal conditions, operating experience, and industry trends to make informed decisions about safety enhancements to their facilities.

The NRC does not specifically mandate some of these reviews. Rather, they are self-imposed initiatives over and above regulations, motivated by the licensees' self-described pursuit of excellence and by the recognition that, in the US free-market competitive energy industry, safety and economics are directly linked. Licensees have, for example, voluntarily replaced analog instrumentation and control systems with digital systems, upgraded their plants, replacing or enhancing major nuclear components, to increase production of electricity, and managed their plants to performance levels above the NRC's performance indicator thresholds.

Under the US regulatory structure, Appendix B to 10 CFR Part 50 requires that all nuclear power plant licensees maintain a QA programme. QA comprises all those planned and systematic actions necessary to provide adequate confidence that an SSC will perform satisfactorily in service. QA includes quality control, which comprises those QA actions related to the physical characteristics of a material, structure, component, or system that provide a means to control quality to predetermined requirements.

Licensees carry out a comprehensive system of planned and periodic audits to verify compliance with all aspects of the QA programme and to determine the effectiveness of the programme. Appropriately trained personnel who do not have direct responsibilities in the areas being audited perform these audits in accordance with written procedures or checklists. Audit results are documented and reviewed by management with responsibility in the area audited, and appropriate follow-up is initiated.

8. Summary

In general, PSRs are comprehensive assessments:

• to determine, at the time of the review, whether the plant complies with its licensing basis

• to identify the extent to which the current licensing basis remains valid, in part by determining the extent to which the plant meets current safety standards and practices

• to provide a basis for implementing appropriate safety improvements, corrective actions, or process improvements

• to provide confidence that the plant can continue to be operated safely

The USA meets these objectives through a robust regulatory process that provides a foundation for ongoing assessments, evaluations, and when appropriate, imposition of new requirements. The NRC and the US nuclear industry consider new information, in a more risk-informed manner, as it becomes available; adjust the regulatory oversight and plant safety priority, respectively; and provide ongoing assurance that the licensing basis for the design and operation of all nuclear power plants provides an acceptable level of safety.

Second, the NRC and the US nuclear industry have a 30-year history of implementing broad-based plant assessments. The regulatory history of implementing broad-based assessments is a direct result of an adaptive, probing, and independent regulatory process. These assessments have included the SEP, the ISAP, the IPE, and the reactor license renewal process and provide additional confidence that plant safety continues to be the highest priority and that the NRC and industry continue to pursue enhancements that improve safety. Over a period of almost 25 years, broad-based NRC assessments and regulatory initiatives have provided a continuum of assessment, improvement, and oversight, which ensures that licensed plants continue to operate safely.

The NRC's approach to continuing to ensure plant safety differs from the historically deterministic focus of PSRs. The transition to a more risk-informed regulatory framework and the Reactor Oversight Process provides an ongoing approach and basis for implementing appropriate safety improvements, corrective actions, or process improvements and provides confidence that the plant can continue to be operated safely. The NRC's more risk-informed approach helps ensure that resources are optimally focused on those issues most important to safety.

Finally, US licensees establish performance expectations above the thresholds required by the NRC. These self-imposed expectations and initiatives—over and above the regulations—result from the licensee's self-described motivation to pursue excellence and by the recognition that, in the free-market competitive industry in the United States, safety and economics are directly linked.

Annex V

EXAMPLE OF A PSR SCOPE AND METHODOLOGY DOCUMENT FOR THE SAFETY FACTOR HUMAN FACTORS

Prior to commencing the review activities some Member States such as the Republic of Korea have prepared a PSR scope and methodology document which defines the review methodology for each safety factor/review area. For example, the human factors safety factor has to be reviewed according to the Korean Detailed Guidelines for PSR as described below:

V-1. HUMAN FACTORS

1. Area of Review

The objective of this review is to verify the state of management of human factors aspects that would affect the safe operation of power plants. The main categories of the review should cover the Clauses 6, 7, and 9 “Particulars Regarding the Use of Experience from Other Power Plants and Research Findings”, “C. Clarity of Procedures in Consideration of the Principle of Human Factors”, and “Particulars Regarding Human Factors” of Article 19-2 of the Enforcement Regulations of the Atomic Energy Act (Detailed Contents of the Periodic Safety Evaluation) and Clause 7 “C. Clarity of Procedures in Consideration of the Principle of Human Factors”. The details of review areas are as follows:

(1) Staffing levels for the operation of the nuclear power plant recognizing absence, shit working, and overtime restrictions
(2) Availability of quantified staff on duty at all times.
(3) Programmes for initial, refresher and upgrade training, including the use of simulators.
(4) Human information requirements and workload.
(5) Human-system interface including control room and other workstation design.

2. Acceptance Criteria

The review should verify that:

(1) The applicant has identified plans to evaluate the state of management of human factors aspects in accordance with the requirement of Article 19-2 of the Enforcement Regulations of the Atomic Energy Act (General Contents of the Periodic Safety Evaluation).
(2) The applicant has an human factors evaluation team with the responsibility, authority, placement within PSR organization, and composition to ensure that the appropriate evaluation is achieved.
(3) The applicant has performed evaluation by the current and latest safety standards, methods, practices, and knowledge for each review area.
(4) The applicant has verified the shortcomings by assessing of the current and latest safety standards and practices.
(5) The applicant has proposed the appropriate remedial and corrective actions and measures for the shortcomings.

3. Review Procedures

The applicant should submit review materials for each review area. The staff should review the applicant’s submittals with the following procedures:

(1) The staff should ensure that the applicant has covered all items of human factors review as stated in "1. Area of Review."

(2) The staff should confirm on the appropriateness of the selected objectives and acceptance criteria of evaluation, methods, and practices. In this procedure, the staff can refer to ANSI/ANS 3.1 [V-1], 3.2 [V-2], and 3.5 [V-3] and NUREG-0800 [V-4], 0711 [V-5], 0700 [V-6], and 0737 [V-7].

(3) The staff should verify that the applicant has completed remedial and corrective actions and measures for each of the shortcomings. When it is not applicable to complete the actions and measures within the time-scale of the PSR, schedules of implementation plan should be agreed upon between the applicant and the regulator.

4. Evaluation Findings

The staff should states the comprehensive results and findings of the PSR in the evaluation report including: the degree of implementation of the applicant's management of human factors in accordance with Clauses 6, 7, and 9 of Article 19-2 of the Enforcement Regulations of the Atomic Energy Act; future plans for the improvement of safety; and whether the plans will perform their functions during the operation period of next 10 years.

5. Implementation

Except those cases in which the applicant proposes an acceptable alternative method, the reviewer conducts the review in accordance with the guidelines described herein.

REFERENCES TO ANNEX V

[V-1] ANS, "Selection, Qualification, and Training of Personnel for Nuclear Power Plants", ANSI/ANS-3.1, 1993.

[V-2] ANS, "Administrative Controls and Quality Assurance for the Operational Phase of Nuclear Power Plants", ANSI/ANS-3.2, 1994.

[V-3] ANS, "Nuclear Power Plants Simulators for use in Operator Training and Examination", ANSI/ANS-3.5, 1993.

[V-4] US NRC, "Standard Review Plan; 18.0 Human Factors Engineering", NUREG-0800 Rev. 1, 2004.

[V-5] US NRC, "Human Factors Engineering Program Review Model", NUREG-0711 Rev. 2, 2004.

[V-6] US NRC, "Human-System Interface Design Review Guidelines", NUREG-0700 Rev. 1, 2004.

[V-7] US NRC, "Clarification of TMI Action Plan Requirements; Requirements for Emergency Response Capability", NUREG-0737 Supplement 1, 1982.

CONTRIBUTORS TO DRAFTING AND REVIEW

BANKS, P. J.	British Energy, UK
BERG, H. P.	Bundesamt für Strahlenschutz, Germany
ISHACK, G.	Canadian Nuclear Safety Commission, Canada
JANSEN, R.	Ministry of Housing Spatial Planning & Environment, Netherlands
KATONA, T.J.	Paks Nuclear Power Plant, Hungary
KIM, M.W.	Korea Institute of nuclear Safety, Republic of Korea
KOTYZA, V.	Consultant, Czech Republic
LEMAY, M.	Canadian Nuclear Safety Commission, Canada
MILLER, D.	Canadian Nuclear Safety Commission, Canada
SHIM, S.	Canadian Nuclear Safety Commission, Canada
SMITH, N.	Ontario Power Generation, Canada
SWCHWARZ, G.	Canadian Nuclear Safety Commission, Canada
TOTH, C.	International Atomic Energy Agency
WEST, B.	Health and Safety Executive, UK
ZIMMERMAN, J.	Nuclear Regulatory Commission, USA

Meetings

Consultants Meetings, Vienna, Austria, 17-19 December 2008; 22-25 October 2007;
14-18 May 2007; 9-12 October 2006; 3-7 July 2006; 11-14 September 2006

Technical Committee Meetings, Vienna, Austria, 8-10 November 2006; 27-29 October 2004

No. 21, July 2006

IAEA
International Atomic Energy Agency

Where to order IAEA publications

In the following countries IAEA publications may be purchased from the sources listed below, or from major local booksellers. Payment may be made in local currency or with UNESCO coupons.

Australia
DA Information Services, 648 Whitehorse Road, Mitcham Victoria 3132
Telephone: +61 3 9210 7777 • Fax: +61 3 9210 7788
Email: service@dadirect.com.au • Web site: http://www.dadirect.com.au

Belgium
Jean de Lannoy, avenue du Roi 202, B-1190 Brussels
Telephone: +32 2 538 43 08 • Fax: +32 2 538 08 41
Email: jean.de.lannoy@infoboard.be • Web site: http://www.jean-de-lannoy.be

Canada
Bernan Associates, 4611-F Assembly Drive, Lanham, MD 20706-4391, USA
Telephone: 1-800-865-3457 • Fax: 1-800-865-3450
Email: order@bernan.com • Web site: http://www.bernan.com

Renouf Publishing Company Ltd., 1-5369 Canotek Rd., Ottawa, Ontario, K1J 9J3
Telephone: +613 745 2665 • Fax: +613 745 7660
Email: order.dept@renoufbooks.com • Web site: http://www.renoufbooks.com

China
IAEA Publications in Chinese: China Nuclear Energy Industry Corporation, Translation Section, P.O. Box 2103, Beijing

Czech Republic
Suweco CZ, S.R.O. Klecakova 347, 180 21 Praha 9
Telephone: +420 26603 5364 • Fax: +420 28482 1646
Email: nakup@suweco.cz • Web site: http://www.suweco.cz

Finland
Akateeminen Kirjakauppa, PL 128 (Keskuskatu 1), FIN-00101 Helsinki
Telephone: +358 9 121 41 • Fax: +358 9 121 4450
Email: akatilaus@akateeminen.com • Web site: http://www.akateeminen.com

France
Form-Edit, 5, rue Janssen, P.O. Box 25, F-75921 Paris Cedex 19
Telephone: +33 1 42 01 49 49 • Fax: +33 1 42 01 90 90 • Email: formedit@formedit.fr

Lavoisier SAS, 14 rue de Provigny, 94236 Cachan Cedex
Telephone: + 33 1 47 40 67 00 • Fax +33 1 47 40 67 02
Email: livres@lavoisier.fr • Web site: http://www.lavoisier.fr

Germany
UNO-Verlag, Vertriebs- und Verlags GmbH, August-Bebel-Allee 6, D-53175 Bonn
Telephone: +49 02 28 949 02-0 • Fax: +49 02 28 949 02-22
Email: info@uno-verlag.de • Web site: http://www.uno-verlag.de

Hungary
Librotrade Ltd., Book Import, P.O. Box 126, H-1656 Budapest
Telephone: +36 1 257 7777 • Fax: +36 1 257 7472 • Email: books@librotrade.hu

India
Allied Publishers Group, 1st Floor, Dubash House, 15, J. N. Heredia Marg, Ballard Estate, Mumbai 400 001,
Telephone: +91 22 22617926/27 • Fax: +91 22 22617928
Email: alliedpl@vsnl.com • Web site: http://www.alliedpublishers.com

Bookwell, 24/4800, Ansari Road, Darya Ganj, New Delhi 110002
Telephone: +91 11 23268786, +91 11 23257264 • Fax: +91 11 23281315
Email: bookwell@vsnl.net • Web site: http://www.bookwellindia.com

Italy
Libreria Scientifica Dott. Lucio di Biasio “AEIOU”, Via Coronelli 6, I-20146 Milan
Telephone: +39 02 48 95 45 52 or 48 95 45 62 • Fax: +39 02 48 95 45 48

Japan
Maruzen Company, Ltd., 13-6 Nihonbashi, 3 chome, Chuo-ku, Tokyo 103-0027
Telephone: +81 3 3275 8582 • Fax: +81 3 3275 9072
Email: journal@maruzen.co.jp • Web site: http://www.maruzen.co.jp

Korea, Republic of
KINS Inc., Information Business Dept. Samho Bldg. 2nd Floor, 275-1 Yang Jae-dong SeoCho-G, Seoul 137-130
Telephone: +02 589 1740 • Fax: +02 589 1746
Email: sj8142@kins.co.kr • Web site: http://www.kins.co.kr

Netherlands
Martinus Nijhoff International, Koraalrood 50, P.O. Box 1853, 2700 CZ Zoetermeer
Telephone: +31 793 684 400 • Fax: +31 793 615 698 • Email: info@nijhoff.nl • Web site: http://www.nijhoff.nl

Swets and Zeitlinger b.v., P.O. Box 830, 2160 SZ Lisse
Telephone: +31 252 435 111 • Fax: +31 252 415 888 • Email: infoho@swets.nl • Web site: http://www.swets.nl

New Zealand
DA Information Services, 648 Whitehorse Road, MITCHAM 3132, Australia
Telephone: +61 3 9210 7777 • Fax: +61 3 9210 7788
Email: service@dadirect.com.au • Web site: http://www.dadirect.com.au

Slovenia
Cankarjeva Zalozba d.d., Kopitarjeva 2, SI-1512 Ljubljana
Telephone: +386 1 432 31 44 • Fax: +386 1 230 14 35
Email: import.books@cankarjeva-z.si • Web site: http://www.cankarjeva-z.si/uvoz

Spain
Díaz de Santos, S.A., c/ Juan Bravo, 3A, E-28006 Madrid
Telephone: +34 91 781 94 80 • Fax: +34 91 575 55 63 • Email: compras@diazdesantos.es
carmela@diazdesantos.es • barcelona@diazdesantos.es • julio@diazdesantos.es
Web site: http://www.diazdesantos.es

United Kingdom
The Stationery Office Ltd, International Sales Agency, PO Box 29, Norwich, NR3 1 GN
Telephone (orders): +44 870 600 5552 • (enquiries): +44 207 873 8372 • Fax: +44 207 873 8203
Email (orders): book.orders@tso.co.uk • (enquiries): book.enquiries@tso.co.uk • Web site: http://www.tso.co.uk

On-line orders:
DELTA Int. Book Wholesalers Ltd., 39 Alexandra Road, Addlestone, Surrey, KT15 2PQ
Email: info@profbooks.com • Web site: http://www.profbooks.com

Books on the Environment:
Earthprint Ltd., P.O. Box 119, Stevenage SG1 4TP
Telephone: +44 1438748111 • Fax: +44 1438748844
Email: orders@earthprint.com • Web site: http://www.earthprint.com

United Nations (UN)
Dept. I004, Room DC2-0853, First Avenue at 46th Street, New York, N.Y. 10017, USA
Telephone: +800 253-9646 or +212 963-8302 • Fax: +212 963-3489
Email: publications@un.org • Web site: http://www.un.org

United States of America
Bernan Associates, 4611-F Assembly Drive, Lanham, MD 20706-4391
Telephone: 1-800-865-3457 • Fax: 1-800-865-3450
Email: order@bernan.com • Web site: http://www.bernan.com

Renouf Publishing Company Ltd., 812 Proctor Ave., Ogdensburg, NY, 13669
Telephone: +888 551 7470 (toll-free) • Fax: +888 568 8546 (toll-free)
Email: order.dept@renoufbooks.com • Web site: http://www.renoufbooks.com

Orders and requests for information may also be addressed directly to:

Sales and Promotion Unit, International Atomic Energy Agency
Vienna International Centre, PO Box 100, 1400 Vienna, Austria
Telephone: +43 1 2600 22529 (or 22530) • Fax: +43 1 2600 29302
Email: sales.publications@iaea.org • Web site: http://www.iaea.org/books