

IAEA Safety Standards

for protecting people and the environment

Equipment Qualification for Nuclear Installations

Specific Safety Guide

No. SSG-69



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International Atomic Energy Agency



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IAEA SAFETY STANDARDS

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

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

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

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

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

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The IAEA provides for the application of the standards and, under the terms of Articles III and VIII.C of its Statute, makes available and fosters the exchange of information relating to peaceful nuclear activities and serves as an intermediary among its Member States for this purpose.

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EQUIPMENT QUALIFICATION FOR NUCLEAR INSTALLATIONS

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

IAEA SAFETY STANDARDS SERIES No. SSG-69

EQUIPMENT QUALIFICATION FOR NUCLEAR INSTALLATIONS

SPECIFIC SAFETY GUIDE

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2021

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FOREWORD

by Rafael Mariano Grossi
Director General

The IAEA's Statute authorizes it to "establish...standards of safety for protection of health and minimization of danger to life and property". These are standards that the IAEA must apply to its own operations, and that States can apply through their national regulations.

The IAEA started its safety standards programme in 1958 and there have been many developments since. As Director General, I am committed to ensuring that the IAEA maintains and improves upon this integrated, comprehensive and consistent set of up to date, user friendly and fit for purpose safety standards of high quality. Their proper application in the use of nuclear science and technology should offer a high level of protection for people and the environment across the world and provide the confidence necessary to allow for the ongoing use of nuclear technology for the benefit of all.

Safety is a national responsibility underpinned by a number of international conventions. The IAEA safety standards form a basis for these legal instruments and serve as a global reference to help parties meet their obligations. While safety standards are not legally binding on Member States, they are widely applied. They have become an indispensable reference point and a common denominator for the vast majority of Member States that have adopted these standards for use in national regulations to enhance safety in nuclear power generation, research reactors and fuel cycle facilities as well as in nuclear applications in medicine, industry, agriculture and research.

The IAEA safety standards are based on the practical experience of its Member States and produced through international consensus. The involvement of the members of the Safety Standards Committees, the Nuclear Security Guidance Committee and the Commission on Safety Standards is particularly important, and I am grateful to all those who contribute their knowledge and expertise to this endeavour.

The IAEA also uses these safety standards when it assists Member States through its review missions and advisory services. This helps Member States in the application of the standards and enables valuable experience and insight to be shared. Feedback from these missions and services, and lessons identified from events and experience in the use and application of the safety standards, are taken into account during their periodic revision.

I believe the IAEA safety standards and their application make an invaluable contribution to ensuring a high level of safety in the use of nuclear technology. I encourage all Member States to promote and apply these standards, and to work with the IAEA to uphold their quality now and in the future.

THE IAEA SAFETY STANDARDS

BACKGROUND

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

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

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

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

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

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

THE IAEA SAFETY STANDARDS

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

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

Safety measures and security measures¹ have in common the aim of protecting human life and health and the environment. Safety measures and security measures must be designed and implemented in an integrated manner so that security measures do not compromise safety and safety measures do not compromise security.

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

Safety Fundamentals

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

Safety Requirements

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

Safety Guides

Safety Guides provide recommendations and guidance on how to comply with the safety requirements, indicating an international consensus that it

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

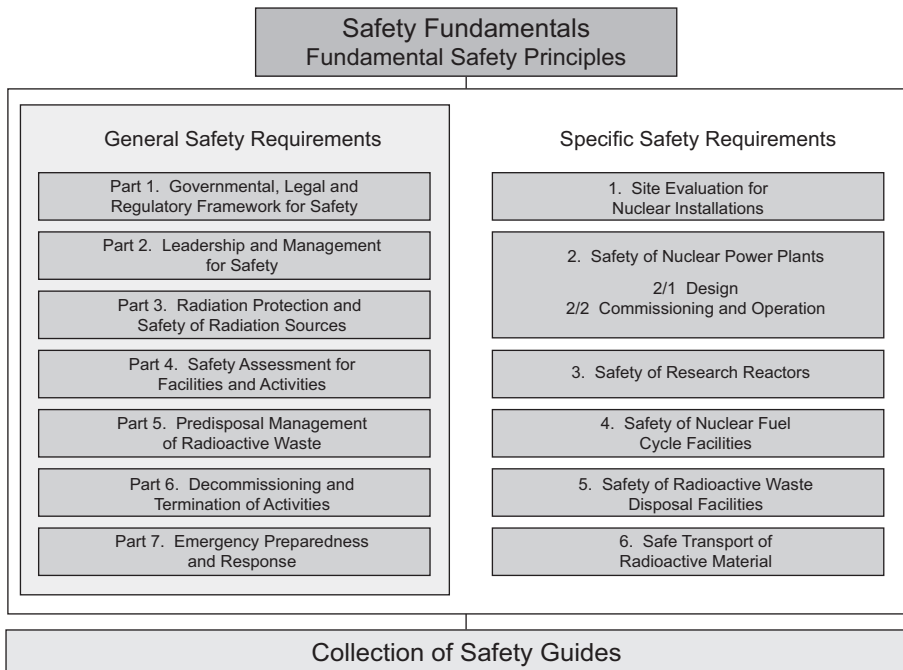


FIG. 1. The long term structure of the IAEA Safety Standards Series.

is necessary to take the measures recommended (or equivalent alternative measures). The Safety Guides present international good practices, and increasingly they reflect best practices, to help users striving to achieve high levels of safety. The recommendations provided in Safety Guides are expressed as ‘should’ statements.

APPLICATION OF THE IAEA SAFETY STANDARDS

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

The IAEA safety standards are applicable, as relevant, throughout the entire lifetime of all facilities and activities — existing and new — utilized for peaceful purposes and to protective actions to reduce existing radiation risks. They can be

used by States as a reference for their national regulations in respect of facilities and activities.

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

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

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

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

DEVELOPMENT PROCESS FOR THE IAEA SAFETY STANDARDS

The preparation and review of the safety standards involves the IAEA Secretariat and five Safety Standards Committees, for emergency preparedness and response (EPReSC) (as of 2016), nuclear safety (NUSSC), radiation safety (RASSC), the safety of radioactive waste (WASSC) and the safe transport of radioactive material (TRANSSC), and a Commission on Safety Standards (CSS) which oversees the IAEA safety standards programme (see Fig. 2).

All IAEA Member States may nominate experts for the Safety Standards Committees and may provide comments on draft standards. The membership of the Commission on Safety Standards is appointed by the Director General and includes senior governmental officials having responsibility for establishing national standards.

A management system has been established for the processes of planning, developing, reviewing, revising and establishing the IAEA safety standards.

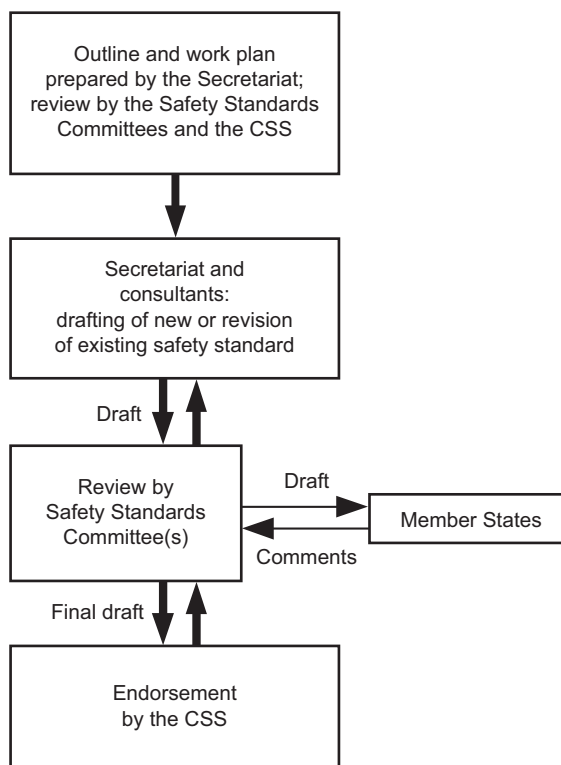


FIG. 2. The process for developing a new safety standard or revising an existing standard.

It articulates the mandate of the IAEA, the vision for the future application of the safety standards, policies and strategies, and corresponding functions and responsibilities.

INTERACTION WITH OTHER INTERNATIONAL ORGANIZATIONS

The findings of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) and the recommendations of international expert bodies, notably the International Commission on Radiological Protection (ICRP), are taken into account in developing the IAEA safety standards. Some safety standards are developed in cooperation with other bodies in the United Nations system or other specialized agencies, including the Food and Agriculture Organization of the United Nations, the United Nations Environment Programme, the International Labour Organization, the OECD Nuclear Energy Agency, the Pan American Health Organization and the World Health Organization.

INTERPRETATION OF THE TEXT

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

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

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

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

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1. INTRODUCTION

BACKGROUND

1.1. This Safety Guide provides recommendations on equipment qualification¹ in nuclear installations to provide confirmation of the reliable performance of safety functions by such equipment in operational states and accident conditions and to avoid vulnerability due to common cause failure of the equipment.

1.2. Requirements relevant to equipment qualification in nuclear installations are established in the following publications:

- IAEA Safety Standards Series No. SSR-2/1 (Rev. 1), Safety of Nuclear Power Plants: Design [1];
- IAEA Safety Standards Series No. SSR-2/2 (Rev. 1), Safety of Nuclear Power Plants: Commissioning and Operation [2];
- IAEA Safety Standards Series No. SSR-3, Safety of Research Reactors [3];
- IAEA Safety Standards Series No. SSR-4, Safety of Nuclear Fuel Cycle Facilities [4].

1.3. Several other IAEA safety standards also have some relevance to equipment qualification. These include the following:

- IAEA Safety Standards Series No. GSR Part 4 (Rev. 1), Safety Assessment for Facilities and Activities [5].
- IAEA Safety Standards Series No. GSR Part 2, Leadership and Management for Safety [6], and its supporting Safety Guides, IAEA Safety Standards Series Nos GS-G-3.1, Application of the Management System for Facilities and Activities [7], and GS-G-3.5, The Management System for Nuclear Installations [8].
- IAEA Safety Standards Series No. SSG-30, Safety Classification of Structures, Systems and Components in Nuclear Power Plants [9].
- IAEA Safety Standards Series Nos: SSG-34, Design of Electrical Power Systems for Nuclear Power Plants [10]; SSG-39, Design of Instrumentation

¹ 'Equipment qualification' refers to the generation and maintenance of evidence to ensure that equipment will operate on demand, under specified service conditions, to meet system performance requirements.

and Control Systems for Nuclear Power Plants [11]; SSG-37, Instrumentation and Control Systems and Software Important to Safety for Research Reactors [12]; SSG-48, Ageing Management and Development of a Programme for Long Term Operation of Nuclear Power Plants [13]; and SSG-10, Ageing Management for Research Reactors [14].

1.4. The terms used in this Safety Guide are to be understood as defined and explained in the IAEA Safety Glossary [15]. Definitions for certain terms used in this Safety Guide that are not in the IAEA Safety Glossary are provided at the end of this publication.

OBJECTIVE

1.5. The objective of this Safety Guide is to provide recommendations on a structured approach to the establishment and preservation of equipment qualification in nuclear installations to meet the relevant requirements established in SSR-2/1 (Rev. 1) [1], SSR-2/2 (Rev. 1) [2], SSR-3 [3] and SSR-4 [4].

1.6. This Safety Guide is intended for use by organizations responsible for aspects of equipment qualification for nuclear installations. This Safety Guide is also intended for use by regulatory bodies to support their licensing and inspection activities relating to equipment qualification.

SCOPE

1.7. The recommendations in this Safety Guide apply to new nuclear installations and, as far as is reasonably practicable, to existing nuclear installations.

1.8. This Safety Guide applies primarily to equipment that performs one or more safety functions, but it may also be applied to items not important to safety, in accordance with national requirements.

1.9. This Safety Guide applies to electrical equipment, instrumentation and control and active mechanical equipment, as well as components associated with this equipment (e.g. seals, gaskets, lubricants, cables, connections, mounting and anchoring structures).

1.10. The qualification process for passive mechanical components (e.g. piping, vessels), for which the safety performance is ensured by design in accordance with applicable codes, is outside the scope of this Safety Guide.

1.11. This Safety Guide does not specify seismic qualification methods and processes. Recommendations on seismic qualification for nuclear power plants are provided in IAEA Safety Standards Series No. SSG-67, Seismic Design for Nuclear Installations [16].

1.12. This Safety Guide also does not specify methods for the validation of electromagnetic compatibility. Information and guidance on the validation of electromagnetic compatibility are provided in IEC 61000-4-1 [17].

1.13. This Safety Guide does not provide recommendations on equipment protection against the effects of internal fires and explosions. Recommendations on this topic are provided in IAEA Safety Standards Series No. SSG-64, Protection against Internal Hazards in the Design of Nuclear Power Plants [18].

1.14. The verification and validation of computer software and firmware are out of the scope of this Safety Guide; recommendations on these topics are provided in SSG-39 [11] and SSG-37 [12].

STRUCTURE

1.15. Section 2 provides recommendations regarding the concepts and process of equipment qualification. Section 3 provides recommendations on specifying the design inputs needed to support the qualification process. Section 4 provides recommendations on establishing equipment qualification. Section 5 provides recommendations on preserving equipment qualification, and Section 6 provides recommendations on the evaluation of the effectiveness of the equipment qualification programme. Section 7 provides recommendations on the integration of equipment qualification into other safety programmes and processes.

1.16. The Annex provides a list of international nuclear and non-nuclear standards that can be used for equipment qualification and which have a strong relationship with the major topical areas of this Safety Guide.

2. CONCEPTS AND PROCESS OF EQUIPMENT QUALIFICATION

BASIC CONCEPT OF EQUIPMENT QUALIFICATION

2.1. Requirement 30 of SSR-2/1 (Rev. 1) [1] states:

“A qualification programme for items important to safety shall be implemented to verify that items important to safety at a nuclear power plant are capable of performing their intended functions when necessary, and in the prevailing environmental conditions, throughout their design life, with due account taken of plant conditions during maintenance and testing.”

The same provisions for equipment qualification are established in Requirement 29 of SSR-3 [3] for research reactors, and in Requirement 30 of SSR-4 [4] for nuclear fuel cycle facilities.

2.2. Paragraph 4.48 of SSR-2/2 (Rev. 1) [2] states:

“Appropriate concepts and the scope and process of equipment qualification shall be established, and effective and practicable methods shall be used to upgrade and preserve equipment qualification. A programme to establish, to confirm and to maintain required equipment qualification shall be launched from the initial phases of design, supply and installation of the equipment. The effectiveness of equipment qualification programmes shall be periodically reviewed.”

2.3. Paragraph 4.49 of SSR-2/2 (Rev. 1) [2] states:

“The scope and details of the equipment qualification process, in terms of the required inspection area(s), method(s) of non-destructive testing, possible defects inspected for and required effectiveness of inspection, shall be documented and submitted to the regulatory body for review and approval. Relevant national and international experience shall be taken into account in accordance with national regulations.”

2.4. Paragraph 5.29 of SSR-2/1 (Rev. 1) [1] states (footnote omitted):

“[T]he features that are designed for use in, or that are capable of preventing or mitigating, events considered in the design extension conditions... Shall be capable of performing in the environmental conditions pertaining to these design extension conditions, including design extension conditions in severe accidents, where appropriate”.

2.5. As indicated in para. 2.1, equipment qualification is required to demonstrate that the equipment will be capable of performing its intended safety functions under the range of service conditions specified for the nuclear installation in operational states and accident conditions. This includes an evaluation of the ability of systems or components to perform these safety functions under the effects caused by specified service conditions during plant states and during external events not excluded by the design of the nuclear installation (e.g. seismic events, electromagnetic phenomena such as arcing, lightning). In contrast, internal fires, explosions, internal flooding, tornadoes and hurricanes are not normally considered in equipment qualification because the design generally protects the equipment from the effects of these events.

2.6. Equipment qualification should consider possible synergistic effects (e.g. simultaneous elevated dose rates and temperature, humidity and radiation level), where such effects could lead to significant ageing effects and degradation mechanisms or adverse equipment performance in accident conditions.

2.7. One objective of equipment qualification should be the prevention of common cause failures arising from the exposure of equipment to the specified service conditions.

2.8. The equipment qualification programme should provide confidence that equipment is designed, manufactured, installed, commissioned, operated and maintained such that it is capable of performing its intended safety functions, when needed, under the specified service conditions and throughout its qualified life (see para. 2.15), with due account taken of conditions during maintenance and testing.

2.9. Within the context of equipment qualification, the equipment should be considered an integrated assembly of one or more interconnected components or subassemblies, each with dedicated functionality and specified interfaces to perform or contribute to one or more safety functions.

2.10. The equipment to be qualified should be an accurate representation of the type or series type of the equipment to be installed.

2.11. The qualified configuration of the equipment should include the equipment itself and the equipment it interfaces with. The qualified configuration should include the final versions of firmware, application software and hardware description language, as well as process, electrical and mechanical interfaces, mounting, and equipment orientation.

2.12. Equipment qualification should be considered an essential programme throughout the whole lifetime of a nuclear installation.

OVERVIEW OF THE EQUIPMENT QUALIFICATION PROCESS

2.13. The equipment qualification process comprises three phases:

- (a) Establishment of appropriate design inputs;
- (b) Establishment of equipment qualification process steps;
- (c) Preservation of the status of qualified equipment.

These three phases and the relationship of activities within each phase are considered in Sections 3, 4 and 5, respectively.

QUALIFIED LIFE

2.14. Qualified life² is the period for which a structure, system or component has been demonstrated, through testing, analysis or experience, to be capable of functioning within acceptance criteria during specific operating conditions while retaining the ability to perform its safety functions in accident conditions for a design basis accident or a design basis earthquake [15].

2.15. A qualified life should be established for all equipment that is subject to significant performance degradation mechanisms that could occur under the range of specified service conditions for operational states.

² The term 'qualified life' is not used in all Member States. In some Member States, the term 'qualification for the lifetime of the equipment' serves the same purpose of demonstrating the capability of the equipment to perform its intended safety functions throughout its intended use period and in accident conditions.

2.16. The parameters and any modelling of environmental conditions used to establish the qualified life should be specified. Activities such as monitoring the condition of qualified equipment (see paras 5.22–5.27) and monitoring environmental conditions (see paras 5.18–5.21) should be performed to determine whether these parameters and specified environmental conditions remain within acceptable ranges.

2.17. The qualified life may be based on the performance of the entire equipment assembly or may be dependent on individual components (e.g. gaskets, sealings) within the assembly.

QUALIFICATION METHODS

2.18. Internationally recognized methods for equipment qualification are type testing, analysis, use of operating experience and a combination of these methods. The Annex provides a list of applicable industry standards, which may be considered when identifying appropriate qualification methods.

PRESERVATION OF EQUIPMENT QUALIFICATION

2.19. The preservation of equipment qualification is needed throughout the lifetime of the nuclear installation (see Section 5).

2.20. Justification should be provided during the reassessment of equipment qualification whenever changes occur that could alter the initial equipment qualification.

MANAGEMENT SYSTEM

2.21. Organizations responsible for equipment qualification for nuclear installations are required to develop, implement, assess and continuously improve a management system, which includes quality management, in accordance with the requirements established in GSR Part 2 [6].

2.22. The equipment qualification programme should be subject to a quality assurance programme that includes a variety of elements, such as equipment design control, procurement document control, manufacturing quality control, qualification assessment (e.g. testing, analysis, combined testing and analysis,