

IAEA Safety Standards

for protecting people and the environment

Ageing Management for Nuclear Power Plants

Safety Guide

No. NS-G-2.12



IAEA

International Atomic Energy Agency

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AGEING MANAGEMENT FOR NUCLEAR POWER PLANTS

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

IAEA SAFETY STANDARDS SERIES No. NS-G-2.12

AGEING MANAGEMENT FOR NUCLEAR POWER PLANTS

SAFETY GUIDE

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2009

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FOREWORD

by Mohamed ElBaradei
Director General

The IAEA's Statute authorizes the Agency to establish safety standards to protect health and minimize danger to life and property — standards which the IAEA must use in its own operations, and which a State can apply by means of its regulatory provisions for nuclear and radiation safety. A comprehensive body of safety standards under regular review, together with the IAEA's assistance in their application, has become a key element in a global safety régime.

In the mid-1990s, a major overhaul of the IAEA's safety standards programme was initiated, with a revised oversight committee structure and a systematic approach to updating the entire corpus of standards. The new standards that have resulted are of a high calibre and reflect best practices in Member States. With the assistance of the Commission on Safety Standards, the IAEA is working to promote the global acceptance and use of its safety standards.

Safety standards are only effective, however, if they are properly applied in practice. The IAEA's safety services — which range in scope from engineering safety, operational safety, and radiation, transport and waste safety to regulatory matters and safety culture in organizations — assist Member States in applying the standards and appraise their effectiveness. These safety services enable valuable insights to be shared and I continue to urge all Member States to make use of them.

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

The IAEA takes seriously the enduring challenge for users and regulators everywhere: that of ensuring a high level of safety in the use of nuclear materials and radiation sources around the world. Their continuing utilization for the benefit of humankind must be managed in a safe manner, and the IAEA safety standards are designed to facilitate the achievement of that goal.

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. The safety requirements use 'shall' statements together with statements of

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

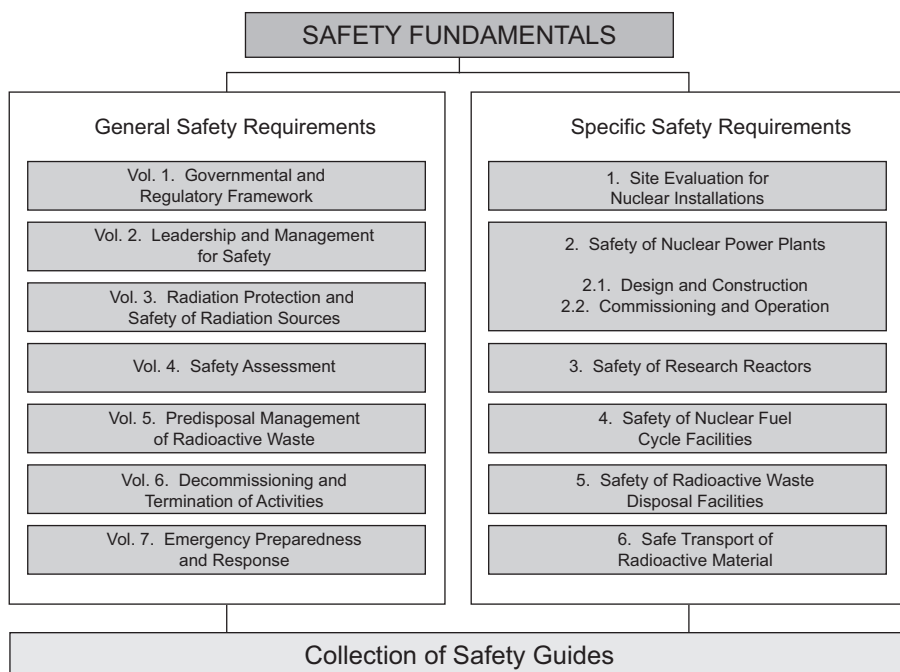


FIG. 1. The long term structure of the IAEA Safety Standards Series.

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

APPLICATION OF THE IAEA SAFETY STANDARDS

The principal users of safety standards in IAEA Member States are regulatory bodies and other relevant national authorities. The IAEA safety

standards are also used by co-sponsoring organizations and by many organizations that design, construct and operate nuclear facilities, as well as organizations involved in the use of radiation and radioactive sources.

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

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

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

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

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

DEVELOPMENT PROCESS FOR THE IAEA SAFETY STANDARDS

The preparation and review of the safety standards involves the IAEA Secretariat and four safety standards committees, for nuclear safety (NUSSC), radiation safety (RASSC), the safety of radioactive waste (WASSC) and the safe transport of radioactive material (TRANSSC), and a Commission on

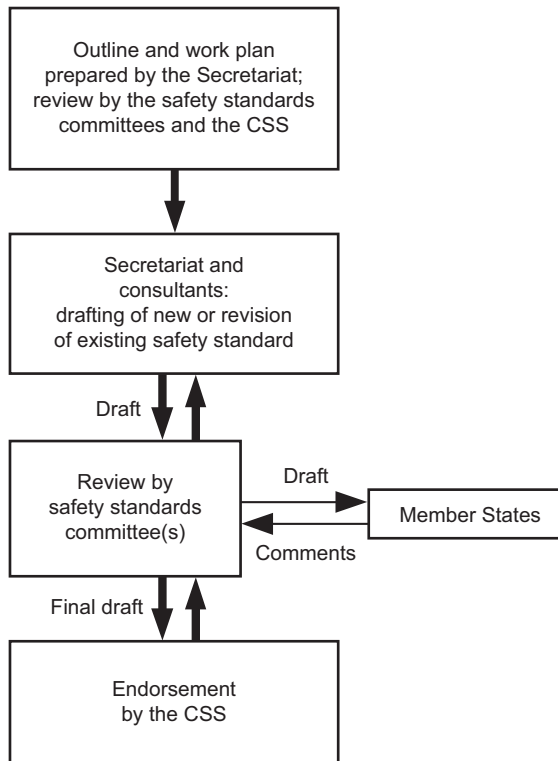


FIG. 2. The process for developing a new safety standard or revising an existing standard.

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

INTERACTION WITH OTHER INTERNATIONAL ORGANIZATIONS

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

INTERPRETATION OF THE TEXT

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

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

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

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

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1. INTRODUCTION

BACKGROUND

1.1. This Safety Guide was prepared under the IAEA's programme for safety standards for nuclear power plants. The requirements for the design and operation of nuclear power plants are established in the Safety Requirements publications on Safety of Nuclear Power Plants: Design [1] and on Safety of Nuclear Power Plants: Operation [2]. The Safety Requirements publication on Legal and Governmental Infrastructure for Nuclear, Radiation, Radioactive Waste and Transport Safety [3] addresses regulatory aspects in all stages of the lifetime of facilities or the duration of activities and for any subsequent period of institutional control until there is no significant residual radiation hazard.

1.2. Managing ageing for nuclear power plants means ensuring the availability of required safety functions throughout the service life of the plant, with account taken of changes that occur with time and use. This requires addressing both physical ageing of structures, systems and components (SSCs), resulting in degradation of their performance characteristics, and obsolescence of SSCs, i.e. their becoming out of date in comparison with current knowledge, standards and regulations, and technology.

1.3. A foundation for effective ageing management is that ageing is properly taken into account at each stage of a plant's lifetime, i.e. in design, construction, commissioning, operation (including long term operation¹ and extended shutdown) and decommissioning.

1.4. Effective management of ageing of SSCs is a key element of the safe and reliable operation of nuclear power plants. In order to assist Member States in managing ageing effectively, the IAEA has developed a comprehensive set of publications. Annex I provides brief descriptions and references for these publications as well as for guidance publications issued by other national and international organizations.

1.5. This Safety Guide supplements and provides recommendations on meeting the requirements set out in Refs [1, 2]. It identifies key elements of

¹ See para. 2.17.

effective ageing management for nuclear power plants, from the publications listed in Annex I and from Member States' experience.

OBJECTIVE

1.6. The objective of this Safety Guide is to provide recommendations for managing ageing of SSCs important to safety in nuclear power plants, including recommendations on key elements of effective ageing management.

1.7. The Safety Guide is intended for use by operators in establishing, implementing and improving systematic ageing management programmes for nuclear power plants. The Safety Guide may be used by regulators in preparing regulatory standards and guides, and in verifying that ageing in nuclear power plants is being effectively managed.

SCOPE

1.8. This Safety Guide deals with the establishment, implementation and improvement of ageing management programmes for SSCs important to safety in nuclear power plants.

1.9. The Safety Guide mainly focuses on managing the physical ageing of SSCs important to safety. It also provides recommendations on safety aspects of managing obsolescence and on the application of ageing management for long term operation. Issues relating to staff ageing and knowledge management are outside the scope of this Safety Guide.

STRUCTURE

1.10. Section 2 presents basic concepts of ageing management, which provide a common basis for the recommendations provided in Sections 3, 4, 5 and 6. Section 3 provides recommendations for the proactive management of the physical ageing of SSCs important to safety throughout the lifetime of a nuclear power plant. Section 4 presents recommendations on a systematic approach to managing ageing in the operation of nuclear power plants. Section 5 presents recommendations on managing obsolescence. Section 6 presents recommendations on the review of the management of ageing in support of long term operation. Section 7 highlights the technical areas of equipment

qualification and periodic safety review that are deemed to be especially significant or closely related to ageing management. The annexes contain supplementary information.

2. BASIC CONCEPTS

2.1. This section presents the basic concepts of management of both ageing and obsolescence, including their application to long term operation, which provide a common basis for the recommendations provided in Sections 3, 4, 5 and 6.

2.2. Nuclear power plants experience two kinds of time dependent changes:

- (i) Physical ageing of SSCs, which results in degradation, i.e. gradual deterioration in their physical characteristics;
- (ii) Obsolescence of SSCs, i.e. their becoming out of date in comparison with current knowledge, standards and technology.

Evaluation of the cumulative effects of both physical ageing and obsolescence on the safety of nuclear power plants is a continuous process and is assessed in a periodic safety review or an equivalent systematic safety reassessment programme (see Section 7).

BASIC CONCEPTS OF MANAGING AGEING

2.3. To maintain plant safety it is very important to detect ageing effects² of SSCs, to address associated reductions in safety margins and to take corrective actions before loss of integrity or functional capability occurs.

² Ageing effects are net changes in the characteristics of an SSC that occur with time or use and which are due to ageing mechanisms. Ageing effects may be positive or negative. Examples of positive effects are increase in concrete strength from curing and reduced vibration from wear-in of rotating machinery. Examples of negative effects are reduction in diameter from wear of a rotating shaft, cracking, thinning or loss in material strength from fatigue or thermal ageing, and loss of dielectric strength or cracking of cable insulation.

2.4. Physical ageing (referred to in this Safety Guide as ageing) of SSCs may increase the probability of common cause failures, i.e. the simultaneous degradation of physical barriers and redundant components, which could result in the impairment of one or more levels of protection provided by the defence in depth concept. Therefore, in the screening of SSCs for ageing management, no account is taken of redundancy or diversity among SSCs [4].

2.5. Effective ageing management is in practice accomplished by coordinating existing programmes, including maintenance, in-service inspection and surveillance, as well as operations, technical support programmes (including analysis of any ageing mechanisms) and external programmes such as research and development. Reference [5] provides guidance on maintenance, surveillance and inspection practices.

2.6. Effective ageing management throughout the service life of an SSC requires the use of a systematic approach to managing ageing that provides a framework for coordinating all programmes and activities relating to the understanding, control, monitoring and mitigation of ageing effects of the plant component or structure. This approach is illustrated in Fig. 1, which is an adaptation of Deming's 'PLAN-DO-CHECK-ACT' cycle to the ageing management of an SSC [6].

2.7. Understanding the ageing of a structure or component, as illustrated in Fig. 1, is the key to its effective ageing management. This understanding is derived from knowledge of:

- The design basis (including applicable codes and standards);
- Safety functions;
- The design and fabrication (including the material, material properties, specific service conditions, manufacturing inspection/examination and testing);
- Equipment qualification (where applicable);
- Operation and maintenance history (including commissioning, repair, modification and surveillance);
- Generic and plant specific operating experience;
- Relevant research results;
- Data and data trends from condition monitoring, inspection and maintenance.

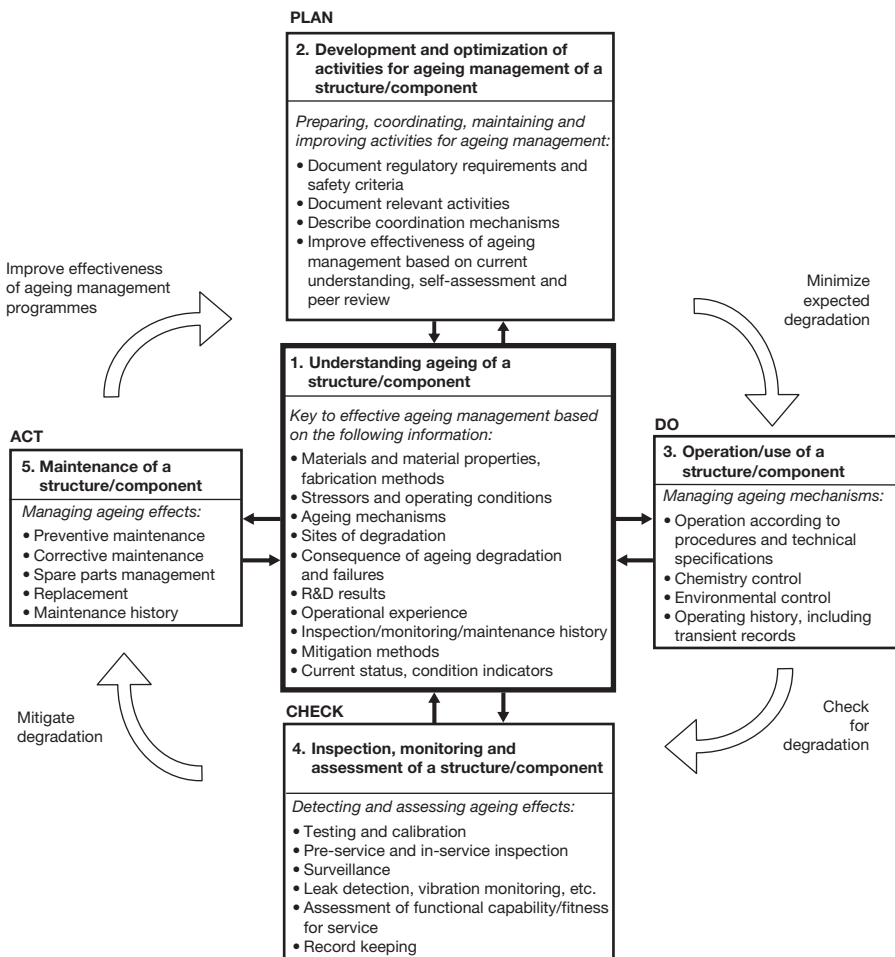


FIG. 1. Systematic approach to managing ageing of a structure or component.

2.8. The PLAN activity in Fig. 1 means coordinating, integrating and modifying existing programmes and activities that relate to managing the ageing of a structure or component and developing new programmes, if necessary.