

IAEA Safety Standards

for protecting people and the environment

Chemistry Programme for Water Cooled Nuclear Power Plants

Specific Safety Guide

No. SSG-13



IAEA

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 at the IAEA Internet site

<http://www-ns.iaea.org/standards/>

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

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OTHER SAFETY RELATED PUBLICATIONS

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CHEMISTRY PROGRAMME
FOR WATER COOLED
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. SSG-13

CHEMISTRY PROGRAMME FOR WATER COOLED NUCLEAR POWER PLANTS

SPECIFIC SAFETY GUIDE

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2011

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FOREWORD

by Yukiya Amano
Director General

The IAEA's Statute authorizes the Agency to “establish or adopt... standards of safety for protection of health and minimization of danger to life and property” — standards that the IAEA must use in its own operations, and which States can apply by means of their regulatory provisions for nuclear and radiation safety. The IAEA does this in consultation with the competent organs of the United Nations and with the specialized agencies concerned. A comprehensive set of high quality standards under regular review is a key element of a stable and sustainable global safety regime, as is the IAEA's assistance in their application.

The IAEA commenced its safety standards programme in 1958. The emphasis placed on quality, fitness for purpose and continuous improvement has led to the widespread use of the IAEA standards throughout the world. The Safety Standards Series now includes unified Fundamental Safety Principles, which represent an international consensus on what must constitute a high level of protection and safety. With the strong support of the Commission on Safety Standards, the IAEA is working to promote the global acceptance and use of its standards.

Standards are only effective if they are properly applied in practice. The IAEA's safety services encompass design, siting and engineering safety, operational safety, radiation safety, safe transport of radioactive material and safe management of radioactive waste, as well as governmental organization, regulatory matters and safety culture in organizations. These safety services assist Member States in the application of the standards and enable valuable experience and insights to be shared.

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

Safety is not an end in itself but a prerequisite for the purpose of the protection of people in all States and of the environment — now and in the future. The risks associated with ionizing radiation must be assessed and controlled without unduly limiting the contribution of nuclear energy to equitable and sustainable development. Governments, regulatory bodies and operators everywhere must ensure that nuclear material and radiation sources are used beneficially, safely and ethically. The IAEA safety standards are designed to facilitate this, and I encourage all Member States to make use of them.

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 is necessary to take the measures recommended (or equivalent alternative measures). The Safety

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

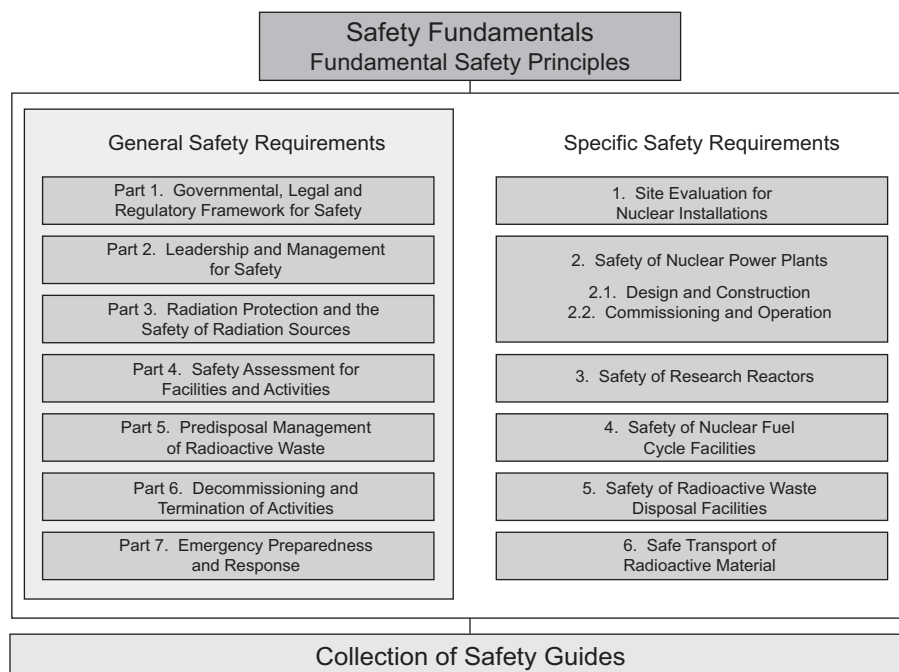


FIG. 1. The long term structure of the IAEA Safety Standards Series.

Guides present international good practices, and increasingly they reflect best practices, to help users striving to achieve high levels of safety. The recommendations provided in Safety Guides are expressed as ‘should’ statements.

APPLICATION OF THE IAEA SAFETY STANDARDS

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

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

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

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

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

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

DEVELOPMENT PROCESS FOR THE IAEA SAFETY STANDARDS

The preparation and review of the safety standards involves the IAEA Secretariat and four safety standards committees, for nuclear safety (NUSSC), radiation safety (RASSC), the safety of radioactive waste (WASSC) and the safe transport of radioactive material (TRANSSC), and a Commission on Safety Standards (CSS) which oversees the IAEA safety standards programme (see Fig. 2).

All IAEA Member States may nominate experts for the safety standards committees and may provide comments on draft standards. The membership of the Commission on Safety Standards is appointed by the Director General and 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

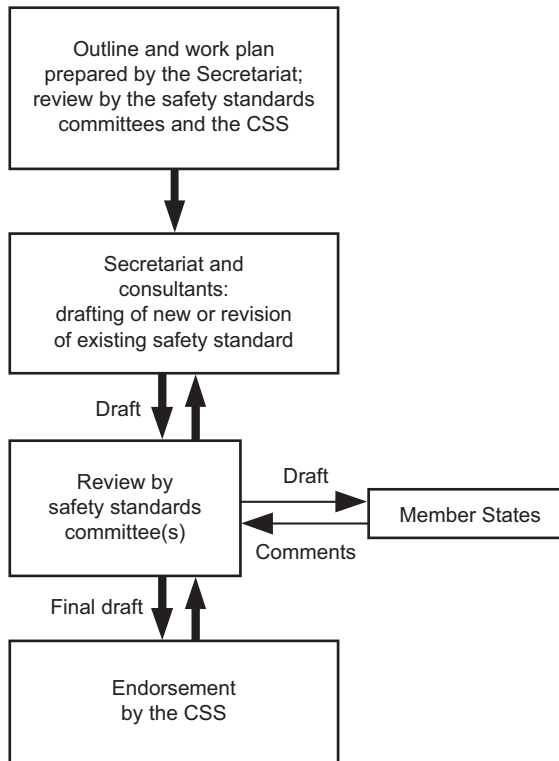


FIG. 2. The process for developing a new safety standard or revising an existing standard.

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 covers all types of nuclear power plant with water cooled reactors and supports the IAEA Safety Requirements publication on Safety of Nuclear Power Plants: Commissioning and Operation [1].

1.2. A chemistry programme is essential for the safe operation of a nuclear power plant. It ensures the integrity, reliability and availability of the main plant structures, systems and components [2] important to safety, in accordance with the assumptions and intent of the design. A chemistry programme minimizes the harmful effects of chemical impurities and corrosion on plant structures, systems and components. It supports the minimization of buildup of radioactive material and occupational radiation exposure as well as limiting of the release of chemicals and radioactive material to the environment.

1.3. This Safety Guide is intended to be useful to plant personnel for maintaining the quality of existing chemistry programmes at a high level and for identifying opportunities for improvement. It can also be used to develop new chemistry programmes as well as to assist in the development of corrective actions for eliminating known weaknesses in current programmes.

1.4. This Safety Guide is also intended to be of use to managers of operating organizations responsible for oversight of the plant chemistry programme and to regulatory bodies.

OBJECTIVE

1.5. The objective of this Safety Guide is to provide Member States with assistance for the safe operation of nuclear power plants according to current international best practices for chemistry programmes. The objective is also to provide recommendations on supporting the integrity of various barriers with

respect to the potential for corrosion of components, optimizing¹ occupational radiation exposures in the plant and limiting releases of radioactive material and chemicals to the environment.

SCOPE

1.6. This Safety Guide provides Member States with recommendations and guidance for chemistry activities to ensure that structures, systems and components important to safety are available to perform their functions in accordance with the assumptions and intent of the design.

1.7. This Safety Guide addresses the main activities of the plant chemistry programme for the various types of water cooled reactor and contains recommendations on chemistry and radiochemistry monitoring to ensure compliance with the appropriate plant operational limits and conditions and to allow proper evaluation of the effectiveness of the plant chemistry programme.

1.8. This Safety Guide does not provide detailed technical advice relating to particular chemistry regimes of nuclear power plants. Such details can be found in IAEA TECDOCs, e.g. Ref. [4]².

STRUCTURE

1.9. Section 2 provides recommendations on the functions and responsibilities of organizations involved in the chemistry programme and the interfaces between them. General recommendations on the chemistry programme are provided in Section 3. Recommendations on the process of chemistry control are provided in Section 4. Recommendations on chemistry aspects of radiation exposure optimization are provided in Section 5. Chemistry surveillance and radiochemistry surveillance processes are discussed in Section 6. Section 7 provides recommendations on the management of chemistry data and Section 8 provides recommendations on the training and qualification of personnel

¹ Optimization of protection (and safety) is the process of determining what level of protection and safety makes exposures, and the probability and magnitude of potential exposures, “as low as reasonably achievable, economic and social factors being taken into account” (ALARA) [3].

² A report setting out guidelines for water chemistry for WWER nuclear power plants is in preparation as part of the IAEA Nuclear Energy Series.

involved in chemistry activities. Recommendations on quality control of chemicals and other substances are provided in Section 9.

2. FUNCTIONS, RESPONSIBILITIES AND INTERFACES

OPERATING ORGANIZATION

2.1. The operating organization is required to establish and implement a chemistry programme to enhance plant and personnel safety, limit environmental discharges and improve plant reliability by:

- (a) Preserving the integrity of structures, systems and components important to safety;
- (b) Minimizing the buildup of radioactive material to reduce dose rates at the plant and hence radiation doses to personnel, to reduce the activity of chemical and radioactive waste and to reduce the activity of any planned discharges to the environment;
- (c) Preserving the integrity of safety barriers for the fuel;
- (d) Controlling the use of soluble poisons.

2.2. The organizational structure of the operating organization should provide for adequate chemistry management at the nuclear power plant [5].

2.3. The operating organization should set challenging goals and objectives for the chemistry programme. The expectations of the management for the implementation of the programme at the plant should be clearly stated. Chemistry staff should understand, support and implement the programme. Feedback on the results of the performance of the chemistry programme should be used to enhance the quality of the chemistry programme and the chemistry regime.

2.4. Information from other utilities and States (e.g. appropriate feedback on operating experience, research results, good practices and standards) should be analysed and incorporated, where considered beneficial, into the chemistry programme. Such information should be made available in the chemistry group and should be kept up to date properly.

2.5. Performance indicators for the chemistry programme should be established to monitor the attainment of goals and objectives and should be promoted and communicated to the staff. Management should periodically reinforce its expectations, monitor and assess performance and correct deviations.

2.6. The operating organization should ensure that the chemistry programme applied to structures, systems and components important to safety is implemented in such a way that the level of reliability and functionality of the structure, system or component remains in accordance with the design assumptions and intent throughout the operating lifetime of the plant.

2.7. The operating organization should provide adequate facilities, sampling and laboratory equipment (including laboratory instruments and on-line instruments) and support for development of methodologies, taking the requirements of the water chemistry programme and appropriate standards into consideration. External contractors and consultants should be made available as necessary to meet analysis needs.

2.8. The operating organization should provide adequate resources, including the requisite number and qualification of chemistry personnel for all levels, such as chemistry staff, supervisors and management, and technical support staff. Planning for continuous improvement should be an established practice among staff in the chemistry group, with account taken of long term operation of the plant.

2.9. Management of the operating organization should periodically evaluate the activities of the chemistry programme by carrying out walkdowns of chemistry facilities and checking plant chemistry equipment. Managers responsible for chemistry programme activities should monitor those indicators of staff behaviour and attitudes that show the development of a strong safety culture (e.g. proper attention to alarms, timely reporting of malfunctions, minimization of backlog of overdue maintenance, adequate labelling, accurate recording of data).

2.10. Managers and supervisors should routinely observe chemistry activities to ensure adherence to plant policies and procedures. Tests after maintenance and modifications should be conducted systematically and thoroughly to ensure that the equipment and systems are ready to return to service. Chemistry performance indicators should be trended, and preventive and/or corrective measures should be undertaken where necessary.

2.11. The plant self-assessment programme should include the chemistry area. In addition, the self-assessment programme should include participation in a recognized analytical certification and intercomparison programme. Audits and other self-assessments and independent reviews of the chemistry programme should be conducted regularly. Non-conformances should be reported and the status of corrective actions should be regularly evaluated [6].

2.12. Management should ensure that any measures to shorten the schedule for planned outage shutdown and to accelerate plant startup will not compromise the full application of chemistry control procedures (e.g. water cleanup during shutdown and startup phases and wet or dry conservation conditions on equipment should be fully respected).

2.13. There should be clear allocation of responsibilities at the plant in accordance with the requirements established in Ref. [7] for all chemistry activities, such as management of resources, chemistry control, dose management, chemistry and radiochemistry surveillance, chemistry and radiochemistry data management, analyses of water chemistry, activity measurement, reviews of results and staff training and qualification.

CONTRACTORS

2.14. The operating organization should ensure that an effective organizational structure is established for contractors working within the chemistry area. The operating organization may delegate to other organizations the task of implementing the chemistry programme or some part thereof, but the operating organization is required to retain overall responsibility for such delegated work [7].

2.15. The operating organization should provide all the information that contractors need and should ensure that contractors understand instructions important to safety.

2.16. Contractors should be made subject to the same standards as plant staff, particularly with respect to required chemistry skills and competences, adherence to procedures, result reporting, safety culture and performance evaluation. Further recommendations on the management of contractors are provided in Ref. [2].