

IAEA Safety Standards

for protecting people and the environment

Design of Auxiliary Systems and Supporting Systems for Nuclear Power Plants

Specific Safety Guide

No. SSG-62



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International Atomic Energy Agency



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DESIGN OF AUXILIARY SYSTEMS AND SUPPORTING SYSTEMS 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. SSG-62

DESIGN OF AUXILIARY SYSTEMS AND SUPPORTING SYSTEMS FOR NUCLEAR POWER PLANTS

SPECIFIC SAFETY GUIDE

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2020

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FOREWORD

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

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

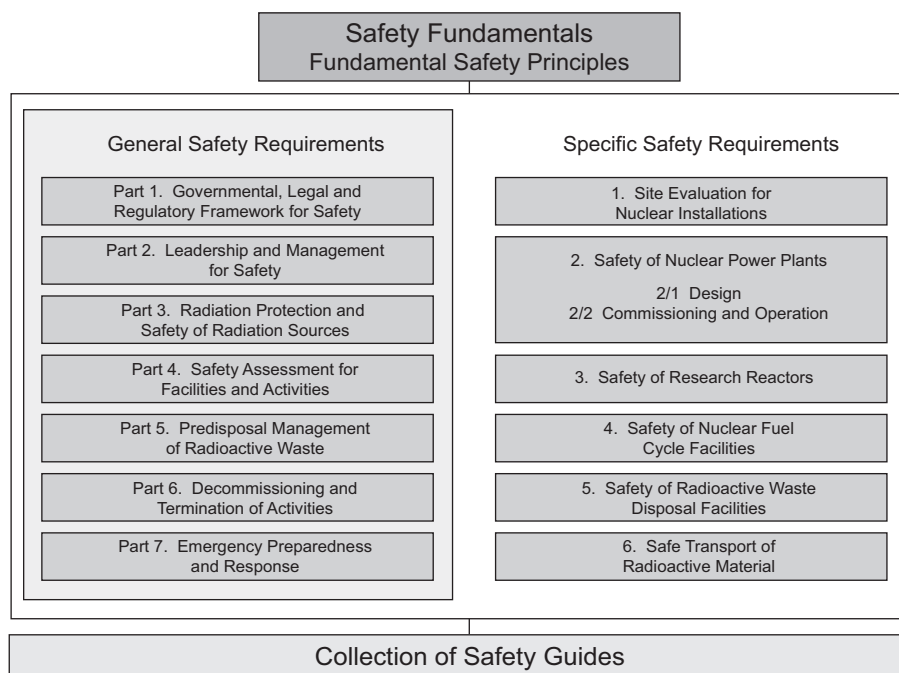


FIG. 1. The long term structure of the IAEA Safety Standards Series.

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.

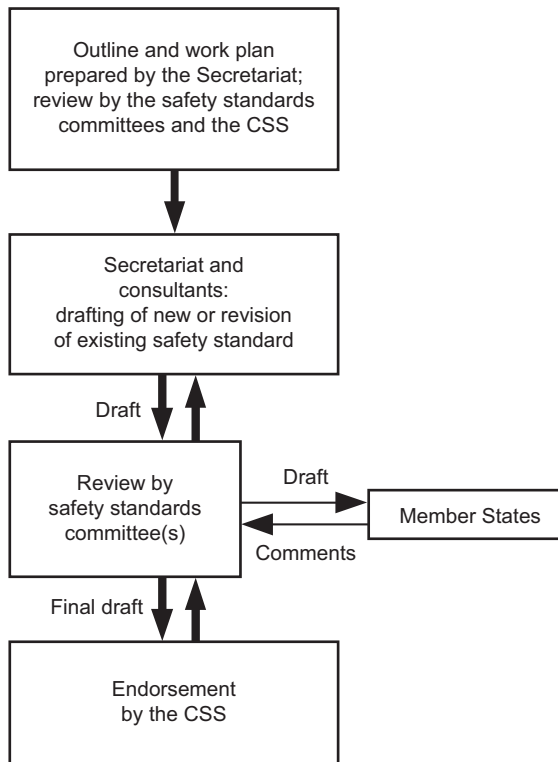


FIG. 2. The process for developing a new safety standard or revising an existing standard.

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 <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 provides recommendations on how to meet the requirements established in IAEA Safety Standards Series No. SSR-2/1 (Rev. 1), Safety of Nuclear Power Plants: Design [1], in relation to the design of auxiliary systems and supporting systems for nuclear power plants.

1.2. Auxiliary systems and supporting systems are those systems that provide electricity, service gas, water, compressed air, air-conditioning, means of communication, means of lifting and lowering items, and fuel and lubricants, all of which are important for the operation and safety of nuclear power plants. The reliability of these systems should be commensurate with their importance for safety.

OBJECTIVE

1.3. The objective of this Safety Guide is to provide recommendations for designers, operating organizations, regulatory bodies and technical support organizations on the design of auxiliary systems and supporting systems to meet the requirements established in SSR-2/1 (Rev. 1) [1] for these systems.

SCOPE

1.4. This Safety Guide provides design recommendations for the auxiliary systems and supporting systems for nuclear power plants with pressurized water reactors, boiling water reactors or pressurized heavy water reactors.

1.5. The list of auxiliary systems and supporting systems considered in this Safety Guide is set out in paras 2.5 and 2.6. The scope does not extend to the detailed design of specific components of these systems, for example heat exchangers.

1.6. The recommendations provided in this Safety Guide are targeted primarily at new nuclear power plants. For nuclear power plants designed to earlier standards, it is expected that in the safety assessments of such designs, a comparison will be made with the current standards (e.g. as part of the periodic safety review for the plant) to determine whether the safe operation of the plant could be further

enhanced by means of reasonably practicable safety improvements (see para. 1.3 of SSR-2/1 (Rev. 1) [1]).

1.7. The terms used in this Safety Guide are to be understood as defined and explained in the IAEA Safety Glossary [2].

STRUCTURE

1.8. Section 2 provides a definition of auxiliary systems and supporting systems and describes their functions and extent. Section 3 describes the general design concepts and design recommendations that are common to the auxiliary systems and supporting systems addressed in the Safety Guide. Section 4 provides recommendations on specific design considerations for a selection of auxiliary systems and supporting systems.

2. GENERAL ASPECTS

DEFINITIONS AND FUNCTIONS OF AUXILIARY SYSTEMS AND SUPPORTING SYSTEMS

2.1. A nuclear power plant has the following main (or primary) systems: the reactor core, the reactor coolant systems, and the containment structure and containment system, as well as their associated safety systems and safety features (see Requirements 43–58 of SSR-2/1 (Rev. 1) [1]). The remaining systems are considered auxiliary systems (see Requirements 59–82 of SSR-2/1 (Rev. 1) [1]) to the main systems and their associated features.

2.2. A stepwise approach to defining auxiliary systems is shown in Fig. 1. An auxiliary system is a system that, on its own, has no primary function in ensuring the operation of the nuclear power plant, but that has to be available for other systems, including the main systems, to carry out their functions.

2.3. Alternatively, an auxiliary system could be a system that provides services for the operation of the nuclear power plant (e.g. communication systems, compressed air system). Auxiliary systems can provide ‘essential services’, namely the resources necessary to maintain the operability of a safety system.

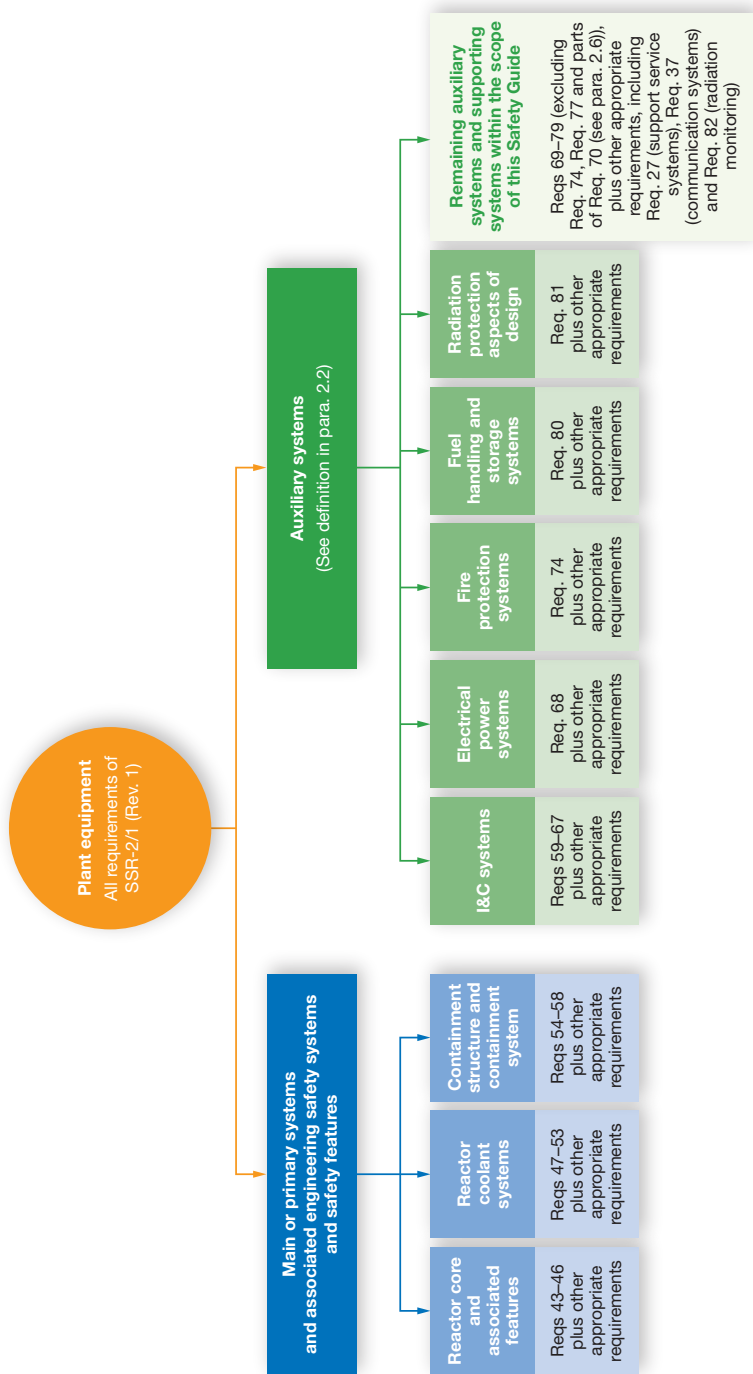


FIG. 1. The auxiliary systems and supporting systems within the scope of this Safety Guide.

They can also provide supplies to systems important to safety. Such supplies could include electricity, water, compressed air, air-conditioning, or fuel and lubricants.

2.4. In this Safety Guide, the term ‘supporting systems’ is used to describe those auxiliary systems that support safety functions.

EXTENT OF THE AUXILIARY SYSTEMS AND SUPPORTING SYSTEMS

2.5. The auxiliary systems and supporting systems addressed in this Safety Guide, as defined in para. 2.2, do not include those systems that are (or are intended to be) addressed in other Safety Guides, as listed below:

- (a) Heat transport systems removing residual heat (Requirement 70 of SSR-2/1 (Rev. 1) [1]) are addressed in detail in IAEA Safety Standards Series No. SSG-56, Design of the Reactor Coolant System and Associated Systems for Nuclear Power Plants [3].
- (b) Fire protection systems (Requirement 74 of SSR-2/1 (Rev. 1) [1]) are addressed in IAEA Safety Standards Series No. NS-G-1.7, Protection against Internal Fires and Explosions in the Design of Nuclear Power Plants [4].
- (c) The steam supply system and feedwater system (Requirement 77 of SSR-2/1 (Rev. 1) [1]) are addressed in SSG-56 [3].
- (d) Radiation protection systems (Requirement 81 of SSR-2/1 (Rev. 1) [1]) are addressed in IAEA Safety Standards Series No. NS-G-1.13, Radiation Protection Aspects of Design for Nuclear Power Plants [5].

2.6. On the basis of paras 2.2 and 2.5, and in accordance with the requirements of SSR-2/1 (Rev. 1) [1], the auxiliary systems and supporting systems considered in this Safety Guide are as follows:

- (a) Communication systems (Requirement 37 of SSR-2/1 (Rev. 1) [1]).
- (b) Heat transport systems (Requirement 70 of SSR-2/1 (Rev. 1) [1]) that are not considered in SSG-56 [3].
- (c) The process and post-accident sampling system (Requirement 71 of SSR-2/1 (Rev. 1) [1]).
- (d) The process radiation monitoring system (Requirement 82 of SSR-2/1 (Rev. 1) [1]).
- (e) The compressed air system (Requirement 72 of SSR-2/1 (Rev. 1) [1]).
- (f) Air-conditioning systems and ventilation systems (Requirement 73 of SSR-2/1 (Rev. 1) [1]).

- (g) Lighting and emergency lighting systems (Requirement 75 of SSR-2/1 (Rev. 1) [1]).
- (h) Overhead lifting equipment (Requirement 76 of SSR-2/1 (Rev. 1) [1]).
- (i) Systems for treatment and control of radioactive waste and radioactive effluents (Requirements 78 and 79 of SSR-2/1 (Rev. 1) [1]).
- (j) Supporting systems for the emergency power supply and the alternate power source (Requirement 68 of SSR-2/1 (Rev. 1) [1]).
- (k) Other systems that are not explicitly indicated in SSR-2/1 (Rev. 1) [1] but that (depending on the design of the nuclear power plant) are usually considered auxiliary systems or supporting systems, such as the following:
 - (i) The equipment and floor drainage system;
 - (ii) The demineralized water reserve and associated system.

SAFETY FUNCTIONS

2.7. Auxiliary systems and supporting systems can directly or indirectly contribute to the fulfilment of safety functions — for example, ensuring essential services (e.g. electrical, pneumatic or hydraulic power supplies or lubrication) — or can provide a supporting function for a safety system or a safety feature for design extension conditions. The safety functions associated with specific auxiliary systems and supporting systems are described in Section 4.

3. GENERAL CONSIDERATIONS IN DESIGN

3.1. This section provides recommendations for design that are common to the auxiliary systems and supporting systems considered in this Safety Guide and that are applicable, as appropriate, to all water cooled reactors. The recommendations in this section are aimed at meeting the requirements established in SSR-2/1 (Rev. 1) [1] for auxiliary systems and supporting systems, in particular Requirement 69 on the performance of auxiliary systems and supporting systems, which states that:

“The design of supporting systems and auxiliary systems shall be such as to ensure that the performance of these systems is consistent with the safety significance of the system or component that they serve at the nuclear power plant.”

OBJECTIVES OF THE DESIGN

3.2. The design of auxiliary systems and supporting systems should assist in the fulfilment of the fundamental safety functions described in Requirement 4 of SSR-2/1 (Rev. 1) [1]. The specific measures necessary to ensure this will depend on the system, the reactor type, the operating conditions and the plant site conditions.

3.3. The design of the auxiliary systems and supporting systems should be such that (a) safety and security are addressed in an integrated manner and (b) safety measures do not compromise nuclear security and nuclear security measures do not compromise safety. Nuclear security measures should be consistent with the objective and essential elements established in IAEA Nuclear Security Series No. 20 [6] and the recommendations provided in IAEA Nuclear Security Series No. 13 [7].

3.4. The safety class of auxiliary systems and supporting systems, or components of such systems, should be assigned with due consideration of the following:

- (a) The safety class of the systems or components that they support;
- (b) The safety function fulfilled by the systems or components that they support, and for which the operation of the auxiliary systems and supporting systems or components is necessary;
- (c) The consequences of failure of the auxiliary systems and supporting systems.

3.5. Each system providing an essential service should have the capacity, autonomy time¹, availability, robustness and reliability that is commensurate with the associated safety functions and with the maximum necessary demands of the systems that it supports, with appropriate margins.

3.6. For nuclear power plants that rely on the forces of buoyancy or gravity or on stored energy sources to perform a safety function and that contain fewer active components, there might be much less need for safety classified auxiliary systems and supporting systems to support the safety functions.

3.7. The performance of a safety function depends not only on the reliability of the main systems that ensure its fulfilment but also on the reliability of the auxiliary systems and supporting systems that are necessary to support the main systems

¹ 'Autonomy time' refers to the period of time that a system can continue to operate autonomously (e.g. while other systems are unavailable).

in performing this function. Therefore, the reliability and design requirements of auxiliary systems and supporting systems should be commensurate with the reliability of the systems they support. Hence, the design of auxiliary systems and supporting systems should be assessed at the same level of detail as for the main systems they support. In addition, the requirements of SSR-2/1 (Rev. 1) [1] relating to the design basis for structures, systems and components apply, as appropriate, to the design of the structures, systems and components of auxiliary systems and supporting systems.

DESIGN BASIS

General

3.8. The design basis for the safety classified structures, systems and components of auxiliary systems and supporting systems should include any conditions associated with normal operation, anticipated operational occurrences and accident conditions (design basis accidents and design extension conditions) for which the operation of the auxiliary systems and supporting systems is necessary.

3.9. Design conditions and design loads should be calculated, as appropriate, with account taken of bounding cases determined for each of the relevant plant states or hazards.

3.10. The expected performance of the structures, systems and components of auxiliary systems and supporting systems should be derived from the demands induced by the safety functions that the supported systems have to ensure.

3.11. A design basis should be defined for every structure, system and component and should take into account the following (see paras 3.12–3.79):

- (a) The safety functions to be performed by the structure, system or component;
- (b) The postulated initiating events that the structure, system or component has to withstand;
- (c) The loads and load combinations that the structure, system or component has to withstand;
- (d) Protection against the effects of internal hazards;
- (e) Protection against the effects of external hazards;
- (f) Design limits and acceptance criteria (applicable to the design of the structure, system or component);
- (g) Reliability;

- (h) Provision against common cause failures within a system and between systems belonging to different levels of defence in depth;
- (i) The safety classification;
- (j) The environmental conditions considered in the qualification programme;
- (k) Design codes and standards;
- (l) Layout considerations;
- (m) Interface considerations;
- (n) Considerations for a multiple unit nuclear power plant, if appropriate;
- (o) Use of probabilistic safety assessment in the design.

Safety functions

3.12. The safety functions to be fulfilled by an auxiliary system or supporting system and the contribution of each component important to safety should be described in a level of detail sufficient for a correct safety classification.

Postulated initiating events

3.13. The design of the plant should be such that a failure of the auxiliary systems and supporting systems would not lead to a postulated initiating event. If such an event is foreseeable, the design should include appropriate measures for the mitigation of the event, with account taken of the effects of the failure of the auxiliary system or supporting system on other plant systems.

Internal hazards

3.14. Paragraphs 3.15–3.17 provide recommendations on meeting Requirement 17 of SSR-2/1 (Rev. 1) [1], in particular para. 5.16 on internal hazards.

3.15. Internal hazards that should be considered are those of internal origin that could jeopardize the performance of a structure, system or component of an auxiliary system or supporting system. A list of typical internal hazards usually considered is provided below for guidance; however, this list should be supplemented, as necessary, to include design specific hazards relevant for the structures, systems and components of the auxiliary system or supporting system:

- (a) Breaks in high energy systems;
- (b) Heavy load drop;
- (c) Internal missiles;
- (d) Fire and explosions;

- (e) Flooding;
- (f) Electromagnetic interference.

3.16. Layout and design provisions should be provided to protect the structures, systems and components of auxiliary systems and supporting systems against the effects of the internal hazards to be considered in accordance with para. 3.7. For example, where relevant, provision should be made for the following:

- (a) The structures, systems and components of auxiliary systems and supporting systems should be protected against impacts of high energy hazards (internal explosions, internal missiles, pipe whipping, jet impingement, heavy load drops), or else they should be designed to withstand the loads generated by such hazards.
- (b) Redundant systems should be segregated to the extent possible, or else they should be adequately separated and protected, as necessary, to prevent the loss of the safety function performed by the systems.
- (c) The segregation, separation and protection measures implemented should also be adequate to ensure that the system response as modelled in the analysis of postulated initiating events is not compromised by the effects of the hazard.
- (d) A single hazard should not have the potential for a common cause failure between the systems that support safety systems designed to control design basis accidents, and the safety features for design extension conditions, especially accidents with core melting.

3.17. More detailed recommendations are provided in NS-G-1.7 [4] and IAEA Safety Standards Series No. NS-G-1.11, Protection against Internal Hazards other than Fires and Explosions in the Design of Nuclear Power Plants [8].

External hazards

3.18. Paragraphs 3.19–3.28 provide recommendations on meeting Requirement 17 of SSR-2/1 (Rev. 1) [1] in relation to external hazards.

3.19. Auxiliary systems and supporting systems needed to ensure the operation of systems necessary to mitigate accident conditions should be designed to withstand or should be protected against the effects of design basis external hazards and against common cause failure mechanisms that could be generated by those hazards. The design of these auxiliary and supporting systems should be consistent with the design of such mitigatory systems and should give due consideration to the function of the auxiliary systems and supporting systems.

3.20. Any structure, system or component whose failure could compromise the operation of the auxiliary systems and supporting systems described in para. 3.19 should be designed to withstand the same design basis external hazards or be protected against the effects of these design basis external hazards and against common cause failure mechanisms that could be generated by those hazards.

3.21. Any structure, system or component of an auxiliary system or a supporting system whose failure could initiate accident conditions should be designed to withstand or should be protected against the effects of design basis external hazards and against common cause failure mechanisms that could be generated by those hazards.

3.22. For each external hazard, components of auxiliary systems and supporting systems whose operability or integrity is necessary during or after the hazard should be identified and specified in the design basis of the components.

3.23. The design methods and the design and construction codes used should provide adequate margins to avoid cliff edge effects in the event of a slight increase in the severity of the external hazards.

3.24. For external hazards, short term actions that are to be performed by auxiliary systems and supporting systems, and that are necessary to meet the limits and engineering criteria established for the supported system in the event of accident conditions, should be accomplished with on-site systems that are ready to operate in a time commensurate with the short term actions to be taken (see para. 5.17 of SSR-2/1 (Rev. 1) [1]).

3.25. The autonomy time of systems supporting safety functions should be longer than the time at which off-site services are credited. The measures taken at the plant and at the site can be credited in determining this time, provided that the potential for specific hazards to give rise to impacts on several or even all units on the site simultaneously has been considered (see para. 5.15B of SSR-2/1 (Rev. 1) [1]). With regard to external supplies, consideration should be given, as necessary, to the adverse conditions and damage caused by the external hazards.

3.26. Compliance with para. 5.21A of SSR-2/1 (Rev. 1) [1] requires that the structures, systems and components ultimately necessary to prevent an early or large radioactive release are still operable in the event of levels of external natural hazards exceeding those considered for design, with account taken of the hazard evaluation for the site. This applies to auxiliary systems and supporting systems whose operability is necessary for this purpose.

3.27. With regard to external flooding, either all the structures hosting the systems described in para. 3.26 should be located at an elevation higher than the elevation of the design basis flood, or else adequate provisions (e.g. watertight doors) need to be provided in the design to protect these systems and ensure that their safety functions can be maintained.

3.28. More detailed recommendations are provided in IAEA Safety Standards Series No. NS-G-1.5, External Events Excluding Earthquakes in the Design of Nuclear Power Plants [9], and IAEA Safety Standards Series No. NS-G-1.6, Seismic Design and Qualification for Nuclear Power Plants [10].

Accident conditions

3.29. Accident conditions relevant for the design of an auxiliary system or supporting system are those conditions having the potential to jeopardize the safety functions that the auxiliary system or supporting system is contributing to.

3.30. Depending on the design, the failure of certain auxiliary systems and supporting systems has the potential to lead to worse accident conditions, including a severe accident. Therefore, particular attention should be paid to ensuring high reliability of such systems, in particular for accident sequences associated with a loss of off-site power and accident sequences associated with a loss of cooling function or a loss of the ultimate heat sink.

3.31. When considering multiple failures leading to design extension conditions, the failure of auxiliary systems and supporting systems that support safety systems, or that support safety features for design extension conditions without significant fuel degradation, should be taken into account.

3.32. Accident conditions should be used as inputs for determining capabilities, loads and environmental conditions in the design of the parts of the auxiliary systems and supporting systems needed during such conditions.

3.33. More detailed recommendations on meeting Requirements 18–20 of SSR-2/1 (Rev. 1) [1] are provided in IAEA Safety Standards Series No. SSG-2, Deterministic Safety Analysis for Nuclear Power Plants [11].

Reliability

3.34. Paragraphs 3.35–3.47 provide recommendations on meeting Requirements 17, 21–26, 29, 30 and 68 of SSR-2/1 (Rev. 1) [1].

3.35. To achieve the necessary reliability of auxiliary systems and supporting systems that support safety functions, the following factors should be considered:

- (a) Safety classification and the associated engineering requirements for design and manufacturing;
- (b) Design criteria relevant for the systems (e.g. number of redundant trains, seismic qualification, environmental qualification, power supplies);
- (c) Prevention of common cause failures by implementation of suitable measures, such as physical separation and functional independence;
- (d) Layout provisions to protect the systems against the effects of internal and external hazards;
- (e) Periodic testing and inspection;
- (f) Maintenance;
- (g) Use of equipment designed to be fail-safe.

Systems designed to cope with design basis accidents

3.36. The design should be such that the safety functions of safety category 1 or 2 (as defined in IAEA Safety Standards Series No. SSG-30, Safety Classification of Structures, Systems and Components in Nuclear Power Plants [12]), for which a part of an auxiliary system or supporting system is needed in the event of design basis accidents, can be fulfilled despite the consequential failures caused by the postulated initiating event and any single failure postulated for any safety system or safety group necessary to accomplish those safety functions. The unavailability of systems due to maintenance, testing or repair should also be considered.

3.37. The on-site emergency power supply should be designed to have adequate capability to supply power to the electrical equipment necessary to fulfil the safety functions in the event of design basis accidents. Auxiliary systems and supporting systems, and associated equipment, needed in accident conditions should be powered by the emergency power supply or the alternate power source.

3.38. As applicable, vulnerabilities to common cause failures between redundant parts of auxiliary systems and supporting systems that support safety systems should be identified, and design or layout provisions should be implemented to make the redundant parts independent as far as practicable.

3.39. Recommendations relating to the reliability of the systems with regard to the effects of internal hazards, external hazards and environmental conditions are addressed in paras 3.15–3.17, 3.19–3.28 and 3.58–3.65, respectively.

Safety features for design extension conditions without significant fuel degradation

3.40. A reliability analysis of the auxiliary systems and supporting systems that support safety systems designed for given safety functions should be undertaken to identify the need for additional safety features to fulfil these safety functions.

3.41. The more likely combinations of postulated initiating events and common cause failures in redundant safety systems should be analysed. If the consequences exceed the limits for design basis accidents, the vulnerabilities should be removed or additional design features should be implemented to cope with such situations. The additional features for the safety functions that are reactor technology and design dependent should be designed and installed such that they are protected against common cause failures.

3.42. The recommendations in paras 3.36–3.39 should also be applied in respect of design extension conditions without significant fuel degradation, taking into account that meeting the single failure criterion is not required and that the relevant additional safety features are unlikely to fail as a result of the same common cause failures that lead to the failure of systems designed for design basis accidents.

3.43. Any additional safety features for design extension conditions should be supplied by the alternate power source.

Safety features implemented to mitigate the consequences of design extension conditions with core melting

3.44. The auxiliary systems and supporting systems necessary to mitigate the consequences of an accident with core melting are required to be capable of being supplied by any of the available power sources: see para. 6.44B of SSR-2/1 (Rev. 1) [1].

3.45. As far as practicable, independence between safety systems and specific safety features necessary to mitigate the consequences of an accident with core melting should be implemented in the design. In particular, an auxiliary system or a supporting system should not serve both a safety system and a safety feature for a design extension condition with core melting.

3.46. The recommendations in paras 3.36–3.39 should also be applied in respect of design extension conditions with core melting, taking into account that meeting the single failure criterion is not required and that the relevant additional safety