IAEA Safety Standards

for protecting people and the environment

Safety Classification of Structures, Systems and Components in Nuclear Power Plants

Specific Safety Guide

No. SSG-30

IAEA

International Atomic Energy Agency

IAEA SAFETY STANDARDS AND RELATED PUBLICATIONS

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

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: 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.

RELATED PUBLICATIONS

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.

Reports on safety in nuclear activities are issued as **Safety Reports**, which provide practical examples and detailed methods that can be used in support of the safety standards.

Other safety related IAEA publications are issued as **Emergency Preparedness and Response** publications, **Radiological Assessment Reports**, the International Nuclear Safety Group's **INSAG Reports**, **Technical Reports** and **TECDOCs**. The IAEA also issues reports on radiological accidents, training manuals and practical manuals, and other special safety related publications.

Security related publications are issued in the **IAEA Nuclear Security Series**.

The **IAEA Nuclear Energy Series** comprises informational publications to encourage and assist research on, and the development and practical application of, nuclear energy for peaceful purposes. It includes reports and guides on the status of and advances in technology, and on experience, good practices and practical examples in the areas of nuclear power, the nuclear fuel cycle, radioactive waste management and decommissioning.

SAFETY CLASSIFICATION OF
STRUCTURES, SYSTEMS AND
COMPONENTS IN
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-30

SAFETY CLASSIFICATION OF STRUCTURES, SYSTEMS AND COMPONENTS IN NUCLEAR POWER PLANTS

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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.

NOTE BY THE SECRETARIAT

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. The process of developing, reviewing and establishing the IAEA standards involves the IAEA Secretariat and all Member States, many of which are represented on the four IAEA safety standards committees and the IAEA Commission on Safety Standards.

The IAEA standards, as a key element of the global safety regime, are kept under regular review by the Secretariat, the safety standards committees and the Commission on Safety Standards. The Secretariat gathers information on experience in the application of the IAEA standards and information gained from the follow-up of events for the purpose of ensuring that the standards continue to meet users' needs. The present publication reflects feedback and experience accumulated until 2010 and it has been subject to the rigorous review process for standards.

Lessons that may be learned from studying the accident at the Fukushima Daiichi nuclear power plant in Japan following the disastrous earthquake and tsunami of 11 March 2011 will be reflected in this IAEA safety standard as revised and issued 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 measures[1] 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.

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

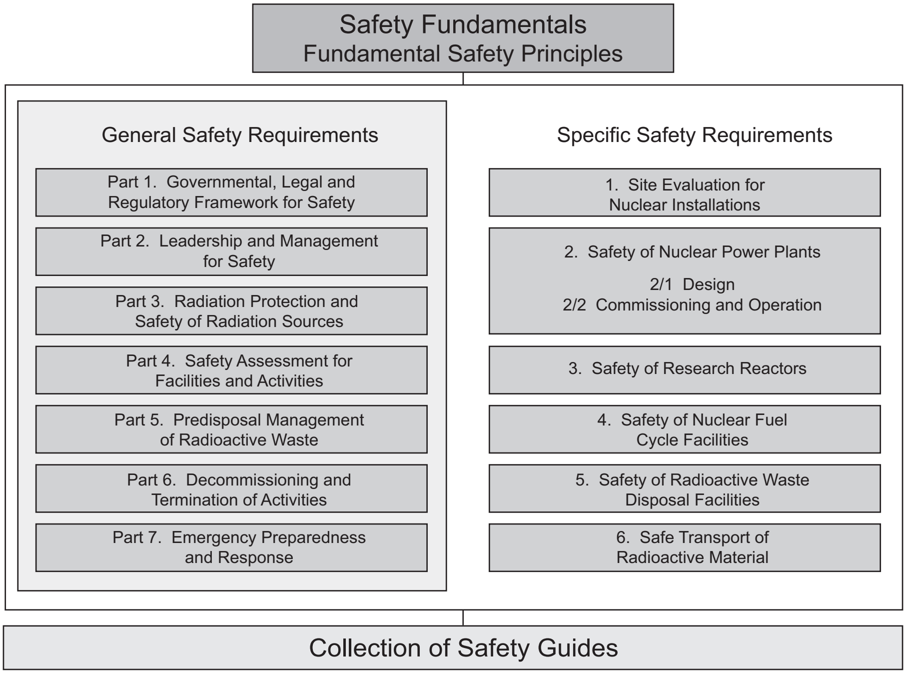

FIG. 1. The long term structure of the IAEA Safety Standards Series.

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 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

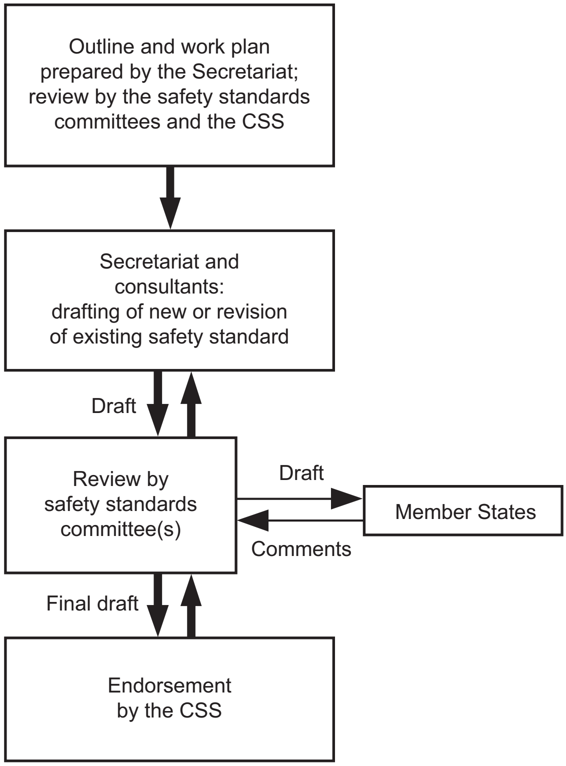

FIG. 2. The process for developing a new safety standard or revising an existing standard.

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.

CONTENTS

1. INTRODUCTION

BACKGROUND

1.1. The need to classify equipment in a nuclear power plant according to its importance to safety has been recognized since the early days of reactor design and operation. The methods for safety classification of structures, systems and components (SSCs) have evolved in the light of experience gained in the design and operation of existing plants. Although the concept of a safety function as being what must be accomplished for safety has been understood for many years, the process by which SSCs important to safety can be derived from the fundamental safety objective has not been described in earlier IAEA Safety Guides dealing with SSC classification. Therefore, the classification schemes used in practice to identify those SSCs deemed to be of the highest importance to safety have, for the most part, been based on experience and analysis of specific designs.

1.2. This Safety Guide was prepared under the IAEA programme for safety standards. A Safety Guide on Safety Functions and Component Classification for BWRs, PWRs and PTRs (i.e. boiling water reactors, pressurized water reactors and pressure tube reactors) was issued in 1979 as IAEA Safety Series No. 50-SG-D1. This was withdrawn in 2000 because the recommendations contained therein were considered not to comply with the IAEA Safety Requirements publication Safety of Nuclear Power Plants: Design (IAEA Safety Standards Series No. NS-R-1), published in 2000.

1.3. In developing this Safety Guide, relevant IAEA publications have also been considered. This includes the Fundamental Safety Principles [1], and the Safety Requirements publications on Safety of Nuclear Power Plants: Design [2] and Safety Assessment for Facilities and Activities [3].

1.4. The goal of safety classification is to identify and classify those SSCs that are needed to protect people and the environment from harmful effects of ionizing radiation, based on their roles in preventing accidents, or limiting the radiological consequences of accidents should they occur. On the basis of their classification, SSCs are then designed, manufactured, constructed, installed, commissioned, operated, tested, inspected and maintained in accordance with established processes that ensure design specifications and the expected levels of safety performance are achieved. In accordance with Ref. [2], all items important to safety are required to be identified and classified on the basis of their functions and their safety significance[1].

1.5. In the preparation of this Safety Guide, the existing safety classification methodologies applied in operating nuclear power plants and for new designs have been broadly reviewed. This Safety Guide describes the steps of safety classification, which are often not expressed and documented in a systematic manner in national classification schemes.

OBJECTIVE

1.6. This publication is intended primarily for use by organizations involved in the design of nuclear power plants, as well as by regulatory bodies and their technical support organizations. It can also be applied to other nuclear installations subject to appropriate adjustments relevant to the specific design of the type of facility being considered.

1.7. The objective of this Safety Guide is to provide recommendations and guidance on how to meet the requirements established in Refs [2, 3] for the identification of SSCs important to safety and for their classification on the basis of their function and safety significance. This is to ensure a high level of safety by meeting the associated quality requirements and reliability targets. The engineering design rules for items important to safety at a nuclear power plant are required to be specified and to comply with the relevant national or international codes and standards and with proven engineering practices, with due account taken of their relevance to nuclear power technology. The nuclear security aspects of the classification of SSCs are outside the scope of this publication. Guidance on these aspects can be found in the publications of the IAEA Nuclear Security Series (e.g. Refs [4, 5]).

SCOPE

1.8. This Safety Guide applies to the design of all SSCs important to safety for all plant states, including all modes of normal operation, during the lifetime of a nuclear power plant.

[1] Factors relevant in determining the safety significance of items important to safety are set out in para. 5.34 in Ref. [2], and for convenience are reproduced in para. 2.2 of this Safety Guide.

1.9. This Safety Guide is written in technology neutral terms. The approach proposed is intended to apply to new nuclear power plants and may not be applicable to existing plants built with earlier classification principles. The manner in which this Safety Guide is applied to such nuclear power plants is a decision for individual States.

STRUCTURE

1.10. Section 2 provides the basis and general approach for identifying the SSCs to be classified and for assessing their individual safety significance on which their ranking is established. Section 3 recommends a process for undertaking the safety classification of SSCs that applies these principles. Section 4 provides general recommendations on selecting the engineering design rules for SSCs on the basis of their safety classes.

2. GENERAL APPROACH

2.1. The general approach is to provide a structure and method for identifying and classifying SSCs important to safety on the basis of their functions and safety significance. Once SSCs are classified, appropriate engineering rules can be applied to ensure that they are designed, manufactured, constructed, installed, commissioned, operated, tested, inspected and maintained with sufficient quality to fulfil the functions that they are expected to perform and, ultimately the main safety functions[2], in accordance with the safety requirements in Ref. [2].

BASIC REQUIREMENTS

2.2. The basic requirements for classification are established in Ref. [2] and are reproduced here for convenience. Additional related requirements are established in Ref. [3].

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[2] According to the IAEA Safety Glossary [6], the functions formerly named 'fundamental safety functions' are now named 'main safety functions'. In quotations from IAEA safety standards, the term 'fundamental safety function' is to be understood to mean 'main safety function'.

“Requirement 4: Fundamental safety functions

“Fulfilment of the following fundamental safety functions for a nuclear power plant shall be ensured for all plant states: (i) control of reactivity, (ii) removal of heat from the reactor and from the fuel store and (iii) confinement of radioactive material, shielding against radiation and control of planned radioactive releases, as well as limitation of accidental radioactive releases.

“4.1. A systematic approach shall be taken to identifying those items important to safety that are necessary to fulfil the fundamental safety functions and to identifying the inherent features that are contributing to fulfilling, or that are affecting, the fundamental safety functions for all plant states.

“4.2. Means of monitoring the status of the plant shall be provided for ensuring that the required safety functions are fulfilled.” [2].

“Requirement 18: Engineering design rules

“The engineering design rules for items important to safety at a nuclear power plant shall be specified and shall comply with the relevant national or international codes and standards and with proven engineering practices, with due account taken of their relevance to nuclear power technology.” [2]

“Requirement 22: Safety classification

“All items important to safety shall be identified and shall be classified on the basis of their function and their safety significance.

“5.34. The method for classifying the safety significance of items important to safety shall be based primarily on deterministic methods complemented, where appropriate, by probabilistic methods, with due account taken of factors such as:

(a) The safety function(s) to be performed by the item;
(b) The consequences of failure to perform a safety function;
(c) The frequency with which the item will be called upon to perform a safety function;

(d) The time following a postulated initiating event at which, or the period for which, the item will be called upon to perform a safety function.

"5.35. The design shall be such as to ensure that any interference between items important to safety will be prevented, and in particular that any failure of items important to safety in a system in a lower safety class will not propagate to a system in a higher safety class.

"5.36. Equipment that performs multiple functions shall be classified in a safety class that is consistent with the most important function performed by the equipment." [2]

"Requirement 27: Support service systems

"Support service systems that ensure the operability of equipment forming part of a system important to safety shall be classified accordingly." [2]

GENERAL RECOMMENDATIONS

2.3. Safety classification is an iterative process that should be carried out periodically throughout the design process and maintained throughout the lifetime of the plant. Any assignment of SSCs to particular safety classes should be justified using deterministic safety analysis complemented by insights from probabilistic safety assessment and supported by engineering judgement.

2.4. Safety classification should be performed during the plant design, system design and equipment design phases, and should be reviewed for any relevant changes during construction, commissioning, operation and subsequent stages of the plant's lifetime.

2.5. New or modified postulated initiating events and SSCs should be addressed in the safety classification process, with account taken of interfaces with existing safety functions and safety classes of the SSCs that may be affected.

2.6. The safety classification process recommended in this Safety Guide is consistent with the concept of defence in depth set out in Ref. [2]. The functions[3] performed at all five levels of defence in depth should be considered and the associated SSCs should then be classified according to their safety significance. Similarly, design provisions should also be classified (see paras 3.8 and 3.9).

2.7. The basis for the classification and the results of the classification should be documented in an auditable record. The final classification of SSCs should be complete and available for audit by the organization(s) responsible for quality assurance and by the regulatory body. As classifications may be affected by subsequent design changes to the plant (throughout its operating life), the classification records should be included in the management system as part of the plant configuration control.

OUTLINE OF THE SAFETY CLASSIFICATION PROCESS

2.8. This Safety Guide proposes a structured process for identifying and classifying the SSCs, which is illustrated in Fig. 1.

2.9. Classification is a top down process that begins with a basic understanding of the plant design, its safety analysis and how the main safety functions will be achieved. Using this information, the functions and design provisions (see para. 3.9) required to fulfil the main safety functions are systematically identified for all plant states, including all modes of normal operation. Using information from safety assessments, such as the analysis of postulated initiating events, the functions are then categorized on the basis of their safety significance. The SSCs belonging to the categorized functions are then identified and classified on the basis of their role in achieving the function. An SSC implemented as a design provision should, however, be classified directly because the significance of its postulated failure fully defines its safety class without any need for detailed analysis of the category of the associated safety function.

[3] For the purpose of this Safety Guide, a function is defined as any action performed by a single SSC or a set of SSCs.

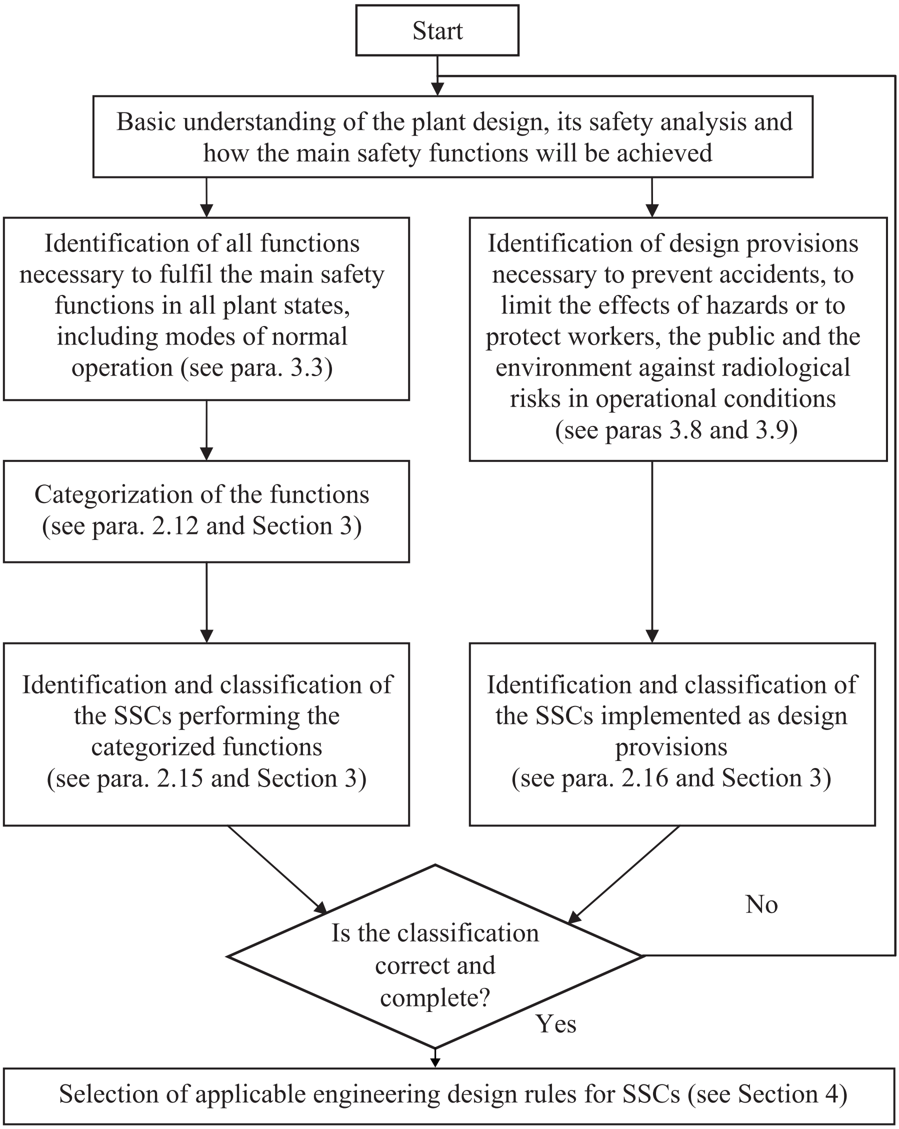

FIG. 1. Flow chart indicating the classification process.

2.10. The process for classifying all SSCs according to their safety significance should take into account the following:

— The plant design and its inherent safety features;
— The list of all postulated initiating events[4], as required in Requirement 16 in Ref. [2]. The frequency of occurrence of the postulated initiating events, as considered in the design of the nuclear power plant, should also be taken into account.

2.11. All functions and design provisions necessary to achieve the main safety functions (as defined in Requirement 4 in Ref. [2]) for the different plant states, including all modes of normal operation, should be identified.

2.12. The functions should then be categorized into a limited number of categories on the basis of their safety significance, using an approach that takes account of the following factors:

(1) The consequences of failure to perform the function;
(2) The frequency of occurrence of the postulated initiating event for which the function will be called upon;
(3) The significance of the contribution of the function in achieving either a controlled state or a safe state (as defined in Ref. [2]).

2.13. Categorization of the functions provided by design provisions is not necessary because the safety significance of the SSC can be derived directly from the consequences of its failure. The SSCs implemented as design provisions can therefore be assigned directly to a safety class without the need for a further analysis of safety function categories.

2.14. The next step in the process is to determine the safety classification of all SSCs important to safety. Deterministic methodologies should generally be applied, complemented where appropriate by probabilistic safety assessment and engineering judgement to achieve an appropriate risk profile, i.e. a plant design for which events with a high level of severity of consequences have a very low predicted frequency of occurrence. The overall intent is illustrated schematically

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[4] As stated in para. 5.9 of Ref. [2], "The postulated initiating events used for developing the performance requirements for the items important to safety in the overall safety assessment and the detailed analysis of the plant shall be grouped into a specified number of representative event sequences that identify bounding cases and that provide the basis for the design and the operational limits for items important to safety."

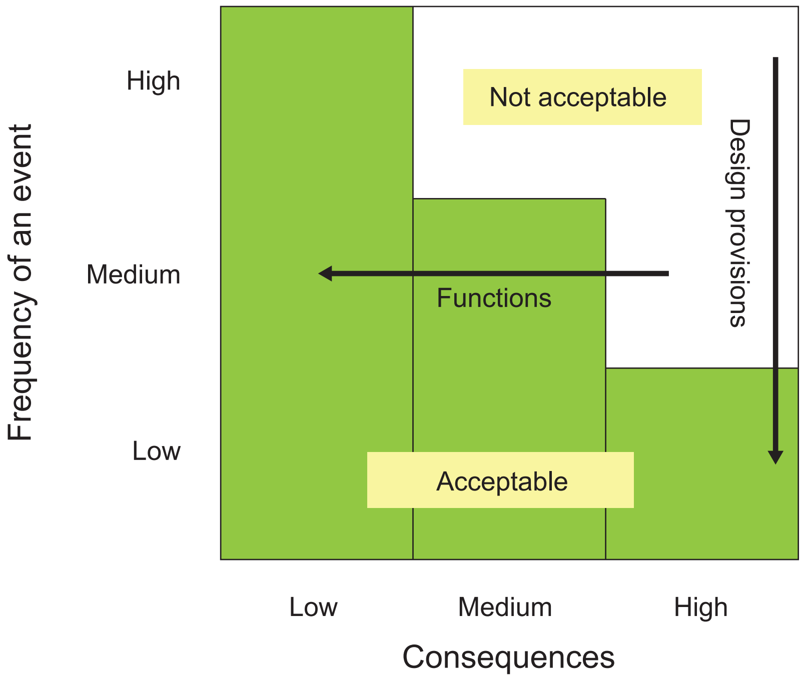

FIG. 2. The basic principle of frequency versus consequences.

in Fig. 2, showing that design provisions are implemented primarily to decrease the probability of an accident and functions are implemented to make the consequences acceptable with regard to its probability. For most initiating events, a combination of both design provisions and functions is implemented to decrease the frequency of occurrence of an accident and to make its consequences acceptable and also as low as practicable. Nevertheless, for a few initiating events, the implementation of functions to limit the consequences may not be necessary provided that the consequences are very low and that there is no need for any mitigation measures. The efficiency of both design provisions and safety functions will depend on the overall dependability of items of equipment, which itself is governed by their classification.

2.15. To decrease the frequency of occurrence of accidents and to make their consequences acceptable and also as low as practicable, the SSCs that are needed to perform functions should be identified and classified into a limited number of classes on the basis of their safety significance, using a process that takes into account the factors indicated in Requirement 22 in Ref. [2].

2.16. The SSCs implemented as design provisions should also be identified and classified using the same set of classes as those used for the classification of SSCs needed to perform safety functions.

2.17. Based on the experience of Member States, in this Safety Guide three safety categories for functions and three safety classes for SSCs important to safety are recommended. Other approaches utilizing a larger or smaller number of categories and classes may be used provided that they are aligned with the guidance provided in paras 2.12 and 2.15.

3. SAFETY CLASSIFICATION PROCESS

3.1. This section provides more detailed guidance on the identification of functions to be categorized and SSCs to be classified to ensure that all items essential to protect people and the environment from harmful effects of ionizing radiation will be captured.

IDENTIFICATION OF FUNCTIONS TO BE CATEGORIZED

3.2. For the purposes of simplification, the term ‘function’ includes the primary function and any supporting functions that are expected to be performed to ensure the accomplishment of the primary function.

3.3. The functions to be categorized are those required to achieve the main safety functions for the different plant states, including all modes of normal operation. These functions are primarily those that are credited in the safety analysis and should include functions performed at all five levels of defence in depth, i.e. prevention, detection, control and mitigation safety functions.

3.4. Although the main safety functions to be fulfilled are the same for every plant state, the functions to be categorized should be identified with respect to each plant state separately.

3.5. The lists of functions identified may be supplemented by other functions, such as those designed to reduce the actuation frequency of the reactor scram and/or engineered safety features that correct deviations from normal operation, including those designed to maintain the main plant parameters within the normal range of operation of the plant. Such functions are generally not credited in the safety analysis.

3.6. Owing to the importance of monitoring to safety, functions for monitoring to provide the plant staff and the off-site emergency response organization with sufficient reliable information in the event of an accident should be considered for safety categorization. This should include monitoring and communication as required under the emergency response plan.

3.7. Functions credited in the safety analysis with either preventing some sequences resulting from additional independent failures from escalating to a severe accident, or mitigating the consequences of a severe accident, are included in functions associated with design extension conditions.

IDENTIFICATION OF DESIGN PROVISIONS

3.8. The safety of the plant is also dependent on the reliability of different types of features, some of which are designed specifically for use in normal operation. For the purpose of this Safety Guide, these SSCs are termed ‘design provisions’. Such design provisions should be identified and may be considered to be subject to the safety classification process, and hence will be designed, manufactured, constructed, installed, commissioned, operated, tested, inspected and maintained with sufficient quality to fulfil their intended role.

3.9. Design provisions should include the following:

— Design features designed to such a quality that their failure could be ‘practically eliminated’[5]. For these design features, the plant design does not require an independent safety system to be available to mitigate the effects of their failure. Examples of these are the shells of reactor pressure vessels or steam generators. These design features can be readily identified by the high level of severity of consequences that can be expected should they fail.
— Features that are designed to reduce the frequency of an accident. Examples of these are piping of high quality whose failure would result in a design basis accident.

[5] The possibility of certain conditions occurring is considered to have been ‘practically eliminated’ if it is physically impossible for the conditions to occur, or if the conditions can be considered with a high level of confidence to be extremely unlikely to arise.

— Passive design features that are designed to protect workers and the public from harmful effects of radiation in normal operation. Examples of these are shielding, civil structures and piping.
— Passive design features that are designed to protect components important to safety from being damaged by internal or external hazards. Examples of these are concrete walls between components that are built specifically for this purpose.
— Features that are designed to prevent a postulated initiating event from developing into a more serious sequence without the occurrence of another independent failure. Examples of these are anti-whipping devices and fixed points.

SSCs implemented as design provisions should be classified as recommended in para. 3.22, depending on the outcome of the assessment of the consequences of their failure.

CATEGORIZATION OF FUNCTIONS

3.10. The functions required for fulfilling the main safety functions in all plant states, including modes of normal operation, should be categorized on the basis of their safety significance. The safety significance of each function is determined by taking account of the factors indicated in para. 2.12. In the approach recommended in this Safety Guide, the severity of consequences (factor 1) is divided into three levels (high, medium and low) on the basis of the worst consequences that could arise if the function were not performed, as defined in para. 3.11.

3.11. The three levels of severity are defined as follows:

— The severity should be considered ‘high’ if failure of the function could, at worst:
  - Lead to a release of radioactive material that exceeds the limits accepted by the regulatory body for design basis accidents; or
  - Cause the values of key physical parameters to exceed acceptance criteria for design basis accidents[6].
— The severity should be considered ‘medium’ if failure of the function could, at worst:

[6] See Requirements 15 and 19 in Ref. [2].

    - Lead to a release of radioactive material that exceeds limits established for anticipated operational occurrences; or
    - Cause the values of key physical parameters to exceed the design limits for anticipated operational occurrences.
- The severity should be considered 'low' if failure of the function could, at worst:
    - Lead to doses to workers above authorized limits.

Where more than one of these definitions is met, the highest of the three levels should be applied. The assessment of the consequences is made under the assumption that the function does not respond when challenged.

For anticipated operational occurrences, in order to avoid 'over-categorization', the assessment of the consequences should be made with the assumption that all other independent functions are performed correctly and in due time.

3.12. Factor 2 (see para. 2.12) reflects the frequency that a function will be called upon. This frequency should be evaluated primarily in accordance with the frequency of occurrence of the respective postulated initiating event.

3.13. By including factors 1 and 2, the approach to classification recommended here is in line with the commonly agreed design principle that events with the most significant consequences ought to have the lowest frequency of occurrence. This means, for example, that functions dedicated to the mitigation of the consequences of severe accidents may involve less stringent engineering design rules than those applied for functions for mitigation of the consequences of design basis accidents, because the frequency of occurrence of severe accidents is lower than that of design basis accidents. Figure 2 illustrates this approach.

3.14. Factor 3 (see para. 2.12) concerns functions intended to reach a particular plant state. Generally, two plant states are distinguished, namely a controlled state[7] and a safe state[7]. For functions that are performed to achieve a controlled state, the main focus is on automatic actuation or short term actuation, in order to reduce considerably the hazard potential. Functions that are applied to achieve a safe state are longer term functions, and are performed once the controlled state has been achieved. In many cases, for reactors, the functions applied following an accident transient will achieve a controlled state first before achieving a safe state. Typical functions for the controlled state are reactor trip, decay heat removal and

[7] Definitions are provided in Ref. [2].

safety injection. Depressurizing the reactor and connecting the residual heat removal system to ensure the long term function of decay heat removal are good examples of functions that are performed to achieve a safe state.

3.15. The categorization of functions recommended in this Safety Guide is based on the following three safety categories:

Safety category 1: Any function that is required to reach the controlled state after an anticipated operational occurrence or a design basis accident and whose failure, when challenged, would result in consequences of ‘high’ severity.

Safety category 2: There are three possibilities in this category:

- — Any function that is required to reach a controlled state after an anticipated operational occurrence or a design basis accident and whose failure, when challenged, would result in consequences of ‘medium’ severity; or
- — Any function that is required to reach and maintain for a long time a safe state and whose failure, when challenged, would result in consequences of ‘high’ severity; or
- — Any function that is designed to provide a backup of a function categorized in safety category 1 and that is required to control design extension conditions without core melt.

Safety category 3: There are five possibilities in this category:

- — Any function that is actuated in the event of an anticipated operational occurrence or design basis accident and whose failure, when challenged, would result in consequences of ‘low’ severity; or
- — Any function that is required to reach and maintain for a long time a safe state and whose failure, when challenged, would result in consequences of ‘medium’ severity; or
- — Any function that is required to mitigate the consequences of design extension conditions, unless already required to be categorized in safety category 2, and whose failure, when challenged, would result in consequences of ‘high’ severity; or
- — Any function that is designed to reduce the actuation frequency of the reactor trip or engineered safety features in the event of a deviation from normal operation, including those designed to maintain the main plant parameters within the normal range of operation of the plant; or

— Any function relating to the monitoring needed to provide plant staff and off-site emergency services with a sufficient set of reliable information in the event of an accident (design basis accident or design extension conditions), including monitoring and communication means as part of the emergency response plan (defence in depth level 5), unless already assigned to a higher category.

3.16. The categorization described in para. 3.15 is summarized in Table 1. Where a function could be considered to be in more than one category (e.g. because the function is needed for more than one postulated initiating event), it should be categorized in the highest of these categories.

TABLE 1. RELATIONSHIP BETWEEN FUNCTIONS CREDITED IN THE ANALYSIS OF POSTULATED INITIATING EVENTS AND SAFETY CATEGORIES

Functions credited in the safety assessment	Severity of the consequences if the function is not performed		
	High	Medium	Low
Functions to reach a controlled state after anticipated operational occurrences	Safety category 1	Safety category 2	Safety category 3
Functions to reach a controlled state after design basis accidents	Safety category 1	Safety category 2	Safety category 3
Functions to reach and maintain a safe state	Safety category 2	Safety category 3	Safety category 3
Functions for the mitigation of consequences of design extension conditions	Safety category 2 or 3 (see para. 3.15)	Not categorized [a]	Not categorized [a]

[a] Medium or low severity consequences are not expected to occur in the event of non-response of a dedicated function for the mitigation of design extension conditions.

3.17. Once the safety categorization of the functions is completed, the SSCs performing these functions should be assigned to a safety class.

3.18. All SSCs required to perform a function that is safety categorized should be identified and classified according to their safety significance following a process that takes into account the factors indicated by Requirement 22 in Ref. [2] and reproduced in para. 2.2.

3.19. By applying factors (a) and (c) defined in para. 2.2, SSCs (including supporting SSCs) that are designed to carry out identified functions should initially be assigned to the safety class corresponding to the safety category of the function to which they belong. In the approach recommended in this Safety Guide, three safety classes are proposed consistent with the three categories recommended in para. 3.15.

3.20. The initial classification should then be amended, as necessary, to take into account factors (b) and (d) defined in para. 2.2. For factor (d), consideration of the time following a postulated initiating event before the function is called upon may permit the SSC to be moved into a lower class, provided that its expected reliability can be demonstrated. Such a demonstration may use, for example, time to repair or maintain the SSC, or the possibility of using alternative SSCs within the time window available to perform the required safety function.

3.21. If an SSC contributes to the performance of several functions of different categories, it should be assigned to the class corresponding to the highest of these categories (i.e. the one requiring the most conservative engineering design rules).

3.22. By applying these and other relevant considerations (e.g. engineering judgement), the final safety class of the SSC should then be selected.

3.23. As explained in para. 2.9, design provisions can be classified directly according to the severity of consequences of their failures:

- *Safety class 1*: Any SSC whose failure would lead to consequences of ‘high’ severity.
- *Safety class 2*: Any SSC whose failure would lead to consequences of ‘medium’ severity.
- *Safety class 3*: Any SSC whose failure would lead to consequences of ‘low’ severity.

Any SSC (for example, a fire or flood barrier) whose failure could challenge the assumptions made in the hazard analysis should be assigned to safety class 3 at the very least.

3.24. Any SSC that does not contribute to any categorized function, but whose failure could adversely affect a categorized function (if this cannot be precluded by design), should be classified appropriately in order to avoid an unacceptable impact from the failure of the function.

3.25. Where the safety class of connecting or interacting SSCs is not the same (including cases where an SSC in a safety class is connected to an SSC that is not classified), interference between the SSCs should be prohibited by means of a device (e.g. an optical isolator or automatic valve) classified in the higher safety class, to ensure that there will be no effects from a failure of the SSC in the lower safety class.

3.26. By assigning each SSC to a safety class, a set of engineering, design and manufacturing rules can be identified and applied to the SSCs to achieve the appropriate quality and reliability. Recommendations on assigning engineering design rules are provided in Section 4.

VERIFICATION OF THE SAFETY CLASSIFICATION

3.27. The adequacy of the safety classification should be verified by using deterministic safety analysis, which should be complemented by insights from probabilistic safety assessment and/or supported by engineering judgement[8].

3.28. The contribution of the SSC to reduction in the overall plant risk is an important factor in the assignment of its safety class. Consistency between the deterministic and probabilistic approaches will provide confidence that the safety classification is correct. Generally, it is expected that probabilistic criteria for safety classification will match those derived deterministically. If there are differences, however, further assessment should be carried out in order to understand the reasons for these and a final safety class should be assigned, which should be supported by an appropriate justification.

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[8] Expert groups providing engineering judgement should include knowledgeable personnel from the operating organization of the plant, and personnel with skills and expertise in probabilistic safety assessment, safety analysis, plant operation, design engineering and systems engineering.

3.29. The process of verification of the safety classification should be iterative, keeping in step with and informing the evolving design.

4. SELECTION OF APPLICABLE ENGINEERING DESIGN RULES FOR STRUCTURES, SYSTEMS AND COMPONENTS

4.1. Engineering design rules are the relevant national or international codes, standards and proven engineering practices that should be applied, as appropriate, to the design of SSCs to meet the applicable design requirements.

4.2. Once the safety classes of the SSCs have been established, corresponding engineering design rules should be specified and applied. The engineering design rules should be chosen so that the plant design meets the objective that the most frequent postulated initiating events yield little or no adverse consequences, while more extreme events (those having the potential for the greatest consequences) have a very low probability of occurrence (see Fig. 2).

4.3. Engineering design rules are related to the three characteristics of capability, reliability (dependability) and robustness:

(a) Capability is the ability of an SSC to perform its designated function as required;
(b) Reliability (dependability) is the ability of an SSC to perform its required function with a sufficiently low failure rate consistent with the safety analysis;
(c) Robustness is the ability to ensure that no operational loads or loads caused by postulated initiating events will adversely affect the ability of the SSC to perform its function.

These characteristics should be defined, with account taken of uncertainties.

4.4. A complete set of engineering design rules should be specified to ensure that the SSCs will be designed, manufactured, constructed, installed, commissioned, operated, tested, inspected and maintained to appropriate quality standards. To achieve this, the design rules should identify appropriate levels of capability, reliability (dependability) and robustness. The design rules should also take due account of regulatory requirements relevant to safety classified SSCs.

4.5. It is reasonable to distinguish between design requirements that apply at the system level and those that apply to individual structures and components:

— Design requirements applied at the system level may include specific requirements, such as single failure criteria, independence of redundancies, diversity and testability.
— Design requirements applied for individual structures and components may include specific requirements such as environmental and seismic qualification, and manufacturing quality assurance procedures. They are typically expressed by specifying the codes or standards that apply.

4.6. The licensee or applicant should provide and justify the correspondence between the safety class and the associated engineering design and manufacturing rules, including the codes and/or standards that apply to each SSC.

4.7. Once the engineering design requirements have been identified for systems and their individual components, it should be verified that the system can perform its function with the reliability that was assumed in the safety analysis.

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