

IAEA SAFETY STANDARDS SERIES

Fire Safety in the Operation of Nuclear Power Plants

SAFETY GUIDE

No. NS-G-2.1



INTERNATIONAL
ATOMIC ENERGY AGENCY
VIENNA

IAEA SAFETY RELATED PUBLICATIONS

IAEA SAFETY STANDARDS

Under the terms of Article III of its Statute, the IAEA is authorized to establish standards of safety for protection against ionizing radiation and to provide for the application of these standards to peaceful nuclear activities.

The regulatory related publications by means of which the IAEA establishes safety standards and measures are issued in the **IAEA Safety Standards Series**. This series covers nuclear safety, radiation safety, transport safety and waste safety, and also general safety (that is, of relevance in two or more of the four areas), and the categories within it are **Safety Fundamentals**, **Safety Requirements** and **Safety Guides**.

Safety Fundamentals (blue lettering) present basic objectives, concepts and principles of safety and protection in the development and application of nuclear energy for peaceful purposes.

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Information on the IAEA's safety standards programme (including editions in languages other than English) is available at the IAEA Internet site

www.iaea.org/ns/coordinet

or on request to the Safety Co-ordination Section, IAEA, P.O. Box 100, A-1400 Vienna, Austria.

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FIRE SAFETY IN THE OPERATION OF 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".

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FOREWORD

by **Mohamed ElBaradei**
Director General

One of the statutory functions of the IAEA is to establish or adopt standards of safety for the protection of health, life and property in the development and application of nuclear energy for peaceful purposes, and to provide for the application of these standards to its own operations as well as to assisted operations and, at the request of the parties, to operations under any bilateral or multilateral arrangement, or, at the request of a State, to any of that State's activities in the field of nuclear energy.

The following advisory bodies oversee the development of safety standards: the Advisory Commission for Safety Standards (ACSS); the Nuclear Safety Standards Advisory Committee (NUSSAC); the Radiation Safety Standards Advisory Committee (RASSAC); the Transport Safety Standards Advisory Committee (TRANSSAC); and the Waste Safety Standards Advisory Committee (WASSAC). Member States are widely represented on these committees.

In order to ensure the broadest international consensus, safety standards are also submitted to all Member States for comment before approval by the IAEA Board of Governors (for Safety Fundamentals and Safety Requirements) or, on behalf of the Director General, by the Publications Committee (for Safety Guides).

The IAEA's safety standards are not legally binding on Member States but may be adopted by them, at their own discretion, for use in national regulations in respect of their own activities. The standards are binding on the IAEA in relation to its own operations and on States in relation to operations assisted by the IAEA. Any State wishing to enter into an agreement with the IAEA for its assistance in connection with the siting, design, construction, commissioning, operation or decommissioning of a nuclear facility or any other activities will be required to follow those parts of the safety standards that pertain to the activities to be covered by the agreement. However, it should be recalled that the final decisions and legal responsibilities in any licensing procedures rest with the States.

Although the safety standards establish an essential basis for safety, the incorporation of more detailed requirements, in accordance with national practice, may also be necessary. Moreover, there will generally be special aspects that need to be assessed by experts on a case by case basis.

The physical protection of fissile and radioactive materials and of nuclear power plants as a whole is mentioned where appropriate but is not treated in detail; obligations of States in this respect should be addressed on the basis of the relevant instruments and publications developed under the auspices of the IAEA.

Non-radiological aspects of industrial safety and environmental protection are also not explicitly considered; it is recognized that States should fulfil their international undertakings and obligations in relation to these.

The requirements and recommendations set forth in the IAEA safety standards might not be fully satisfied by some facilities built to earlier standards. Decisions on the way in which the safety standards are applied to such facilities will be taken by individual States.

The attention of States is drawn to the fact that the safety standards of the IAEA, while not legally binding, are developed with the aim of ensuring that the peaceful uses of nuclear energy and of radioactive materials are undertaken in a manner that enables States to meet their obligations under generally accepted principles of international law and rules such as those relating to environmental protection. According to one such general principle, the territory of a State must not be used in such a way as to cause damage in another State. States thus have an obligation of diligence and standard of care.

Civil nuclear activities conducted within the jurisdiction of States are, as any other activities, subject to obligations to which States may subscribe under international conventions, in addition to generally accepted principles of international law. States are expected to adopt within their national legal systems such legislation (including regulations) and other standards and measures as may be necessary to fulfil all of their international obligations effectively.

EDITORIAL NOTE

An appendix, when included, is considered to form an integral part of the standard and to have the same status as the main text. Annexes, footnotes and bibliographies, if included, are used to provide additional information or practical examples that might be helpful to the user.

The safety standards use the form 'shall' in making statements about requirements, responsibilities and obligations. Use of the form 'should' denotes recommendations of a desired option.

The English version of the text is the authoritative version.

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1. INTRODUCTION

BACKGROUND

1.1. Operational experience gained from incidents in nuclear power plants around the world has continued to demonstrate the vulnerability of safety systems to fire and its effects. Considerable developments have taken place in recent years in the design of and regulatory requirements for fire safety in operating nuclear power plants, resulting in substantial improvements at many plants. If these improvements are to be maintained, a systematic approach to fire safety is necessary for both plants built to modern standards and those built to earlier standards.

1.2. Some IAEA safety standards have addressed fire safety as a design issue. Paragraphs 5.10–5.13 of the relevant Safety Requirements publication [1] give requirements for fire safety in the design of nuclear power plants and a related Safety Guide [2] provides guidance on meeting those requirements.

1.3. Fire safety is important throughout the lifetime of a plant, from design to construction and commissioning, throughout plant operation and in decommissioning. Requirements for fire safety in the operation of nuclear power plants are established in an IAEA Safety Requirements publication [3] (para. 2.30). The present Safety Guide provides guidance on how to meet these requirements by making recommendations on the elements of plant management and operation that are necessary to achieve and maintain satisfactory fire safety.

OBJECTIVE

1.4. This Safety Guide provides guidance for plant managers, operators, safety assessors and regulators on suitable measures for ensuring that an adequate level of fire safety is maintained throughout the lifetime of a nuclear power plant.

SCOPE

1.5. This Safety Guide applies to new and existing nuclear power plants with thermal neutron reactors of types in general use, such as light water reactors, heavy water reactors and gas cooled reactors. The general guidance may also be applicable to a broad range of other types of nuclear installation, but its detailed application will depend on the particular technology and the related fire risks.

1.6. For the purposes of this publication, it is assumed that the design of the nuclear power plant incorporates *fire protection measures that conform to the recommendations given in Ref. [2].* If this is not the case, a comprehensive assessment should be made on the basis of those recommendations, and the implications of any deviations should be fully considered (see para. 2.7.).

1.7. This Safety Guide covers a number of distinct elements which should be considered in the fire safety arrangements for the plant. These are: an application of the principle of defence in depth; a fire protection organization with clearly defined individual responsibilities; a fire prevention and protection programme including administrative procedures for the control of combustible materials and ignition sources; updating of the fire hazard analysis; control of plant modifications; periodic inspection, maintenance and testing (where applicable) of all installed fire protection measures (both passive and active); a quality assurance programme; training of plant personnel; and manual fire fighting capability.

1.8. Throughout this publication, the term 'safety' without qualification is used in relation to the nuclear safety of a plant (see also the Glossary) as distinct from 'fire safety'.

STRUCTURE

1.9. Section 2 discusses the general concept of defence in depth as it applies to fire prevention, detection and extinction. Section 3 makes recommendations on the organization and responsibilities of personnel involved in plant fire safety activities. Sections 4–7 provide guidance on: how the fire hazard analysis should be kept up to date; the need to control plant modifications which could affect fire safety; procedures for the control of combustible materials and ignition sources; and meeting inspection, maintenance and testing requirements for fire protection. Sections 8 and 9 cover manual fire fighting capability and training of plant personnel. Within the context of this Safety Guide, manual fire fighting capability includes consideration of both on-site and off-site resources and covers organization, staffing, equipment, training and planning of fire fighting strategies. Training of plant personnel includes the permanent plant staff as well as contractor personnel who may be temporarily assigned to the plant. Finally, Section 10 addresses the quality assurance programme as it relates to specific fire safety issues, and the need to maintain adequate records and documentation. The Annex provides additional information on inspection, maintenance and testing in the form of a sample list of features, systems, equipment and components to be considered in relation to fire safety.

2. APPLICATION OF DEFENCE IN DEPTH

DEFENCE IN DEPTH

2.1. Principle 11 of the IAEA Safety Fundamentals publication on The Safety of Nuclear Installations [4] is that the design of nuclear installations includes the appropriate application of the defence in depth principle. The concept of defence in depth incorporates multiple levels of protection which are subject to layers of overlapping provisions and should be extended to all safety activities, whether organizational, behavioural or equipment related. These levels of protection are intended to compensate for human errors or plant failures, and should encompass radiation protection and the prevention and mitigation of accidents. Fire is a hazard which has the potential to create a common cause failure mode for which prevention and mitigation measures should be provided.

2.2. To ensure adequate fire safety in a nuclear power plant in operation, an appropriate level of defence in depth should be maintained throughout the lifetime of the plant, through the fulfilment of the three principal objectives identified in Ref. [2]:

- (1) Preventing fires from starting;
- (2) Detecting and extinguishing quickly those fires which do start, thus limiting the damage; and
- (3) Preventing the spread of those fires which have not been extinguished, thus minimizing their effects on essential plant functions.

2.3. It should be ensured by means of the above approach that:

- the probability of a fire occurring is reduced to as low as reasonably practicable;
- safety systems are adequately protected to ensure that the consequences of a single fire will not prevent those systems from performing their required function, account being taken of the effects of a single failure as required by Ref. [1].

2.4. The three objectives of defence in depth listed in para. 2.2. should be achieved through a combination of: design, installation and operation of fire prevention and protection systems; management of fire safety; fire prevention and fire protection measures; quality assurance; and emergency arrangements. These aspects are addressed in the following paragraphs and are considered in more detail in Sections 3–10.

2.5. Finally, an important aspect of defence in depth is the capability to extinguish fires manually. Fires should be fought manually, for example:

- if one or more of the existing active and passive systems fails either to extinguish the fire or to contain it; or
- if a fire occurs in an accessible area not containing fixed fire fighting systems.

In addition, manual fire fighting should be considered a complementary means of fire fighting in support of the main lines of defence against fire provided by the automatic extinguishing systems. The use of or reliance on manual fire fighting should be identified and justified in the fire hazard analysis.

DESIGN

2.6. In any nuclear power plant, every effort should be made to minimize fire risk by design. In general, the fire containment approach is preferred, since it emphasizes passive protection and thus the protection of safety systems does not depend on the operation of a fixed fire extinguishing system.

2.7. For new plants and wherever possible for existing plants, the design for fire protection should satisfy the recommendations specified in Ref. [2]. For existing plants that were not designed in accordance with these recommendations, a comprehensive assessment should be made of the existing fire safety measures on the basis of the recommendations and the implications of any deviations should be fully considered. Where deviations from the recommendations are identified, fire safety should be enhanced or technical justifications should be prepared for not modifying the existing conditions¹. Where design improvements to the fire protection features are identified as necessary, the improvements should, to the extent practicable, follow the recommendations in Ref. [2].

FIRE SAFETY MANAGEMENT

2.8. The operating organization should clearly define in writing the responsibilities of all staff involved in the fire prevention and protection programme and in the fire fighting activities and mitigatory measures (see Section 3).

¹ In some Member States it may be necessary for such technical justifications to be approved by the regulatory body.