

IAEA SAFETY STANDARDS SERIES

Dispersion of Radioactive Material in Air and Water and Consideration of Population Distribution in Site Evaluation for Nuclear Power Plants

SAFETY GUIDE

No. NS-G-3.2



INTERNATIONAL
ATOMIC ENERGY AGENCY
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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.

Safety Requirements (red lettering) establish the requirements that must be met to ensure safety. These requirements, which are expressed as 'shall' statements, are governed by the objectives and principles presented in the Safety Fundamentals.

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**DISPERSION OF
RADIOACTIVE MATERIAL
IN AIR AND WATER AND CONSIDERATION OF
POPULATION DISTRIBUTION IN SITE EVALUATION 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".

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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 bodies oversee the development of safety standards: the Commission for Safety Standards (CSS); the Nuclear Safety Standards Committee (NUSSC); the Radiation Safety Standards Committee (RASSC); the Transport Safety Standards Committee (TRANSSC); and the Waste Safety Standards Committee (WASSC). 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 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. The IAEA issues Safety Requirements and Safety Guides pertaining to nuclear power plants and activities in the field of nuclear energy, on the basis of its Safety Fundamentals publication on The Safety of Nuclear Installations [1]. The present Safety Guide, which supplements the Code on the Safety of Nuclear Power Plants: Siting [2]¹, concerns the effects of a nuclear power plant on the surrounding region and the consideration of population distribution in the siting of a plant.

1.2. This Safety Guide makes recommendations on how to meet the requirements of the Code on the Safety of Nuclear Power Plants: Siting, on the basis of knowledge of the mechanisms for the dispersion of effluents discharged into the atmosphere and into surface water and groundwater. Relevant site characteristics and safety considerations are discussed. Population distribution, the projected population growth rate, particular geographical features, the capabilities of local transport networks and communications networks, industry and agriculture in the region, and recreational and institutional activities in the region should be considered in assessing the feasibility of developing an emergency response plan.

1.3. In the selection of a site for a facility using radioactive material, such as a nuclear power plant, account should be taken of any local features that might be affected by the facility and of the feasibility of off-site intervention, including emergency response and protective actions (see the International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources [3], Appendices IV and V). This is in addition to the evaluation of any features of the site itself that might affect the safety of the facility. This Safety Guide recommends methods for the assessment of regional and local characteristics.

1.4. This Safety Guide supersedes four earlier IAEA Safety Guides, namely: Atmospheric Dispersion in Nuclear Power Plant Siting (Safety Series No. 50-SG-S3 (1980)); Site Selection and Evaluation for Nuclear Power Plants with Respect to Population Distribution (Safety Series No. 50-SG-S4 (1980)); Hydrological Dispersion of Radioactive Material in Relation to Nuclear Power Plant Siting (Safety Series No. 50-SG-S6 (1985)); and Nuclear Power Plant Siting: Hydrogeological Aspects (Safety Series No. 50-SG-S7 (1984)).

¹ To be superseded by a Safety Requirements publication on Safety of Nuclear Power Plants: Site Evaluation, in the Safety Standards Series.

OBJECTIVE

1.5. Radioactive materials discharged from a nuclear power plant might reach the public and might contaminate the environment in the region by way of both direct and indirect pathways. The objective of this Safety Guide is to provide guidance on the studies and investigations necessary for assessing the impact of a nuclear power plant on humans and the environment. It also provides guidance on the feasibility of an effective emergency response plan, in consideration of all the relevant site features.

1.6. This Safety Guide provides guidance on investigations relating to population distribution, and on the dispersion of effluents in air, surface water and groundwater. The guidance is intended to help determine whether the site selected for a nuclear power plant satisfies national requirements and whether possible radiological exposure and hazards to the population and to the environment are controlled within the limits set by the regulatory body, with account taken of international recommendations.

SCOPE

1.7. This Safety Guide provides guidance for the site evaluation stage of a facility, specifically on:

- the development of meteorological, hydrological and hydrogeological descriptions of a plant site;
- programmes to collect meteorological and hydrological data (for surface water and groundwater);
- programmes to collect data on the distribution of the surrounding population in order to demonstrate the feasibility of an effective emergency plan.

1.8. The effects of the proposed plant on the uses of land and water in the region of the site have to be investigated and are covered by this Safety Guide. This is also an aspect that should be considered in the preparation of an emergency plan and in the environmental impact assessment.

1.9. This Safety Guide does not give guidance on dose assessment in relation to the siting of a nuclear power plant. Specific guidance on the calculation of doses and for the identification of characteristics of the site that are relevant to the local and regional radiological impact of a nuclear power plant is given in Refs [4, 5].

1.10. This Safety Guide does not give detailed information on specific methods or mathematical models. Methods for calculating the concentrations and rates of

deposition of radioactive material due to the dispersion of effluents in air or water are presented in Ref. [4]. Attention should be paid to the use of environmental data in conjunction with calculational models to ensure that the type of data is appropriate for the regulatory objective.

STRUCTURE

1.11. Sections 2 and 3 provide guidance on the collection of data on the dispersion of radioactive material in air and water. Sections 4 and 5 provide guidance relating to uses of land and water and to the distribution of the population in the region. Guidance on the site related information necessary for the establishment of an emergency plan is given in Section 6. Guidance on quality assurance considerations is provided in Section 7.

2. TRANSPORT AND DIFFUSION OF EFFLUENTS DISCHARGED INTO THE ATMOSPHERE

GENERAL CONSIDERATIONS

2.1. The atmosphere is a major exposure pathway by which radioactive materials that are either routinely discharged under authorization or accidentally released from a nuclear power plant could be dispersed in the environment and transported to locations where they may reach the public.

2.2. The evaluation of the transport in the atmosphere of radioactive materials discharged from a nuclear power plant under normal operational or accidental conditions is a requirement of design and licensing (Ref. [2], para. 503). A meteorological investigation should be carried out to evaluate regional and site specific meteorological parameters. These data should be collected from appropriate elevations above ground in order to obtain realistic dispersion parameters.

2.3. Contamination in the air, on the ground and in water over short and long time periods should be described in the atmospheric dispersion models, with account taken of diffusion conditions in the region. Orographic elevations having significant slopes should be considered in the models.

2.4. The type and extent of acquired and stored meteorological data should allow for reliable statistical analyses to determine the distribution of radiation exposures.

2.5. The effects and consequences for the public and the environment of short term or long term radioactive discharges should be assessed on the basis of meteorological information and site specific conditions relating to land and water uses, population distribution, infrastructure in the vicinity of the site and relevant radiological parameters.

2.6. A detailed meteorological investigation should be carried out in the region. The calculations of the dispersion and concentrations of radioactive materials should show whether the radiological consequences of routine discharges and potential accidental releases of radioactive materials into the atmosphere are acceptable. The results of these calculations may be used to establish authorized limits for radioactive discharges from the plant into the atmosphere (see Ref. [5]).

2.7. The results of the meteorological investigation should be used to confirm the suitability of a site; to provide a baseline for site evaluation; to determine whether local meteorological characteristics have altered since the site evaluation was made and before operation of the plant commences; to select appropriate dispersion models for the site; to establish limits for radioactive discharges into the atmosphere; to establish limits for design performance (for example, containment leak rates and control room habitability); and to assist in demonstrating the feasibility of an emergency plan.

RADIOACTIVE SOURCE PARAMETERS FOR NORMAL AND ACCIDENTAL DISCHARGES IN AIR

2.8. The following properties and parameters should be estimated for radioactive sources:

- (a) Radioactivity:
 - the rate of discharge of each important nuclide and the total activity of each important nuclide released in a specified period;
 - variation of the rate of discharge of each important nuclide;
- (b) Chemical characteristics of the material released;
- (c) Physical properties of the material released;
- (d) Geometry and mechanics of the discharge.

2.9. Information should be collected on the background levels of activity in air due to natural and artificial sources.