

IAEA SAFETY STANDARDS SERIES

Evaluation of Seismic Hazards for Nuclear Power Plants

SAFETY GUIDE

No. NS-G-3.3



INTERNATIONAL
ATOMIC ENERGY AGENCY
VIENNA



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IAEA SAFETY STANDARDS

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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**.

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EVALUATION OF SEISMIC HAZARDS 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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Printed by the IAEA in Austria
December 2002
STI/PUB/1144

SAFETY STANDARDS SERIES No. NS-G-3.3

EVALUATION OF SEISMIC HAZARDS FOR NUCLEAR POWER PLANTS

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INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2002

IAEA Library Cataloguing in Publication Data

Evaluation of seismic hazards for nuclear power plants : safety guide. —
Vienna : International Atomic Energy Agency, 2002.

p. ; 24 cm. — (Safety standards series, ISSN 1020-525X ;
no. NS-G-3.3)

STI/PUB/1144

ISBN 92-0-117302-4

Includes bibliographical references.

1. Seismology — Research. 2. Earthquake hazard analysis. 3. Nuclear
power plants. I. International Atomic Energy Agency. II. Series.

IAEAL

02-00309

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 on 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. This Safety Guide was prepared under the IAEA programme for safety standards for nuclear power plants. It supplements the Safety Requirements publication on Site Evaluation for Nuclear Facilities that is planned to supersede the Code on the Safety of Nuclear Power Plants: Siting, Safety Series No. 50-C-S (Rev. 1), IAEA, Vienna (1988). The present publication provides guidelines and recommends procedures for the evaluation of seismic hazards for nuclear power plants. It supersedes Safety Series No. 50-SG-S1 (Rev. 1), Earthquakes and Associated Topics in Relation to Nuclear Power Plant Siting, IAEA, Vienna (1991).

1.2. This publication takes into account the following: the need for hazard curves for the probabilistic safety assessment (PSA) of external events for new and existing nuclear facilities; feedback from IAEA reviews of seismic studies for nuclear facilities performed over the past decade; collective knowledge of the effects of significant recent earthquakes; and new approaches in methods of analysis.

1.3. In the site evaluation for a plant, engineering solutions will generally be available to mitigate, by means of certain design features, the potential vibratory effects of earthquakes. However, such solutions cannot always be demonstrated to be adequate for mitigating the effects of phenomena of permanent ground displacement such as surface faulting, subsidence, ground collapse or fault creep.

OBJECTIVE

1.4. The main objective of this Safety Guide is to provide recommendations on how to determine the ground motion hazards for a plant at a particular site and the potential for surface faulting, which could affect the feasibility of construction and safe operation of a plant at that site.

SCOPE

1.5. The guidelines and procedures presented in this Safety Guide can appropriately be used in evaluations of site suitability and seismic hazards for nuclear power plants in any seismotectonic environment. The probabilistic seismic hazard analysis recommended in this Safety Guide also addresses the needs for seismic hazard analysis of external event PSAs conducted for nuclear power plants. Many of the methods and

processes described may also be applicable to nuclear facilities other than power plants. Other phenomena of permanent ground displacement (liquefaction, slope instability, subsidence and collapse) as well as the topic of seismically induced flooding are treated in Safety Guides relating to foundation safety [1] and coastal flooding [2].

STRUCTURE

1.6. Recommendations of a general nature are given in Section 2. Section 3 discusses the acquisition of a database containing the information needed to evaluate and address all hazards associated with earthquakes. Section 4 covers the use of this database for construction of a seismotectonic model. Sections 5 and 6 review ground motion hazards and evaluations of the potential for surface faulting, respectively. Section 7 addresses quality assurance in the evaluation of seismic hazards for nuclear power plants.

2. GENERAL RECOMMENDATIONS

2.1. The hazards of ground motion and faulting associated with earthquakes and geological phenomena shall be investigated for every nuclear power plant. Investigations in this area, which form the basis for technical judgements in the site evaluation for a plant, are treated in this Safety Guide for all levels of exposure to seismic hazards.

2.2. The geological, geophysical and seismological characteristics of the region around the site and the geotechnical characteristics of the site area should be investigated and evaluated as described in this Safety Guide.

2.3. Where necessary, the site region should include areas extending beyond national borders and, for sites located near a coastline, the relevant offshore area. In other words, the database should be homogeneous for the entire region to the extent possible, or, at a minimum, should be sufficiently complete for characterizing, from a seismotectonic point of view, features relevant to the site that are located in other States or in offshore areas.

2.4. The size of the region to be investigated, the type of information to be collected and the scope and detail of the investigations should be determined according to the nature and complexity of the seismotectonic environment.