IAEA SAFETY STANDARDS SERIES

Site Evaluation for Nuclear Installations

SAFETY REQUIREMENTS

No. NS-R-3

IAEA
International Atomic Energy Agency

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.

Safety Guides (green lettering) recommend actions, conditions or procedures for meeting safety requirements. Recommendations in Safety Guides are expressed as 'should' statements, with the implication that it is necessary to take the measures recommended or equivalent alternative measures to comply with the requirements.

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.

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

www-ns.iaea.org/standards/

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

OTHER SAFETY RELATED PUBLICATIONS

Under the terms of Articles III and VIII.C of its Statute, the IAEA 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.

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Other IAEA series that include safety related publications are the **Technical Reports Series,** the **Radiological Assessment Reports Series,** the **INSAG Series, the TECDOC Series**, the **Provisional Safety Standards Series**, the **Training Course Series,** the **IAEA Services Series** and the **Computer Manual Series**, and **Practical Radiation Safety Manuals** and **Practical Radiation Technical Manuals**. The IAEA also issues reports on radiological accidents and other special publications.

SITE EVALUATION FOR NUCLEAR INSTALLATIONS

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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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SITE EVALUATION FOR NUCLEAR INSTALLATIONS

SAFETY REQUIREMENTS

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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 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.

CONTENTS

1. INTRODUCTION

BACKGROUND

1.1. This Safety Requirements publication supersedes the Code on the Safety of Nuclear Power Plants: Siting, which was issued in 1988 as Safety Series No. 50-C-S (Rev. 1). It takes account of developments relating to site evaluations for nuclear installations since the Code on Siting was last revised. These developments include the issuing of the Safety Fundamentals publication on The Safety of Nuclear Installations [1], and the revision of various safety standards and other publications relating to safety. Requirements for site evaluation are intended to ensure adequate protection of site personnel, the public and the environment from the effects of ionizing radiation arising from nuclear installations. It is recognized that there are steady advances in technology and scientific knowledge, in nuclear safety and in what is considered adequate protection. Safety requirements change with these advances and this publication reflects the present consensus among States.

1.2. This Safety Requirements publication was prepared under the IAEA programme on safety standards for nuclear installations. It establishes requirements and provides criteria for ensuring safety in site evaluation for nuclear installations. The Safety Guides on site evaluation listed in the references provide recommendations on how to meet the requirements established in this Safety Requirements publication.

OBJECTIVE

1.3. The objective of this publication is to establish the requirements for the elements of a site evaluation for a nuclear installation so as to characterize fully the site specific conditions pertinent to the safety of a nuclear installation.

1.4. The purpose is to establish requirements for criteria, to be applied as appropriate to site and site–installation interaction in operational states and accident conditions, including those that could lead to emergency measures for:

(a) Defining the extent of information on a proposed site to be presented by the applicant;

(b) Evaluating a proposed site to ensure that the site related phenomena and characteristics are adequately taken into account;
(c) Analysing the characteristics of the population of the region and the capability of implementing emergency plans over the projected lifetime of the plant;
(d) Defining site related hazards.

1.5. This publication does not specifically address underground or offshore installations.

SCOPE

1.6. The scope of this publication encompasses site related factors and site–installation interaction factors relating to plant operational states and accident conditions, including those that could lead to emergency measures, and natural and human induced events external to the installation that are important to safety. The external human induced events considered in this Safety Requirements publication are all of accidental origin. Considerations relating to the physical protection of the installation against wilful actions by third parties are outside its scope.

1.7. The phrase 'external to the installation' is intended to include more than the external zone (see the Glossary). In addition to the area immediately surrounding the site, the site area itself may contain objects that pose a hazard to the installation, such as an oil storage tank for diesel generators or another reactor on a multiunit site.

1.8. The siting process for a nuclear installation generally consists of an investigation of a large region to select one or more candidate sites (site survey)[1], followed by a detailed evaluation of those candidate sites. This publication is primarily concerned with the latter stage.

1.9. Previous safety standards on this subject related to land based, stationary thermal neutron power plants. This Safety Requirements publication has been extended to cover a more comprehensive range of nuclear installations: land based, stationary nuclear power plants and research reactors, as well as nuclear

[1] Site survey is the process that is used to identify preferred candidate sites for nuclear installations on the basis of safety and other considerations.

fuel cycle facilities, including but not limited to enrichment plants, processing plants, independent spent fuel storage facilities and reprocessing plants. In some instances in this publication a requirement is stated to apply to nuclear power plants. In these cases, the requirements are most appropriate for nuclear power plants, but they may also apply to other nuclear installations.

1.10. The level of detail needed in an evaluation to meet the requirements established in this publication will vary according to the type of installation being sited. Nuclear power plants will generally require the highest level of detail. Depending on the level of risk posed by the installation, less detail and smaller areas of coverage may be necessary to comply with the requirements established in this publication.

1.11. This publication is concerned with the evaluation of those site related factors that have to be taken into account to ensure that the site–installation combination does not constitute an unacceptable risk to individuals, the population or the environment over the lifetime of the installation. The evaluation of the non-radiological impacts of a nuclear installation is not considered.

1.12. As used in this publication, the term 'risk' refers to the product derived from the multiplication of the probability of a particular event that results in the release of radioactive material by a parameter corresponding to the radiological consequences of this event. In concept, a comprehensive risk analysis includes all the sequential steps of analysing all the initiating events, following for each initiating event all the possible sequences of subsequent events, associating a probability value with each of these sequences and ending with the consequences for individuals, the population and the environment. In some States, it is an established practice to utilize parts of such a risk analysis and to define probabilistic requirements to supplement traditional deterministic analysis and engineering judgement.

1.13. This publication is concerned mainly with severe events of low probability that relate to the siting of nuclear installations and that have to be considered in designing a particular nuclear installation. If events of lesser severity but higher probability make a significant contribution to the overall risk, they should also be considered in the design of the nuclear installation.

1.14. The scope of the investigation for the site of a nuclear installation covers the entire process of the site evaluation — the selection, assessment, pre-operational and operational stages. The requirements established in this

publication do not apply to the site selection stage, for which a different series of criteria may be used. These may include criteria that have little direct relevance to safety, such as the distance to the planned consumers of the power to be generated.

STRUCTURE

1.15. This Safety Requirements publication follows the relationship between principles and objectives of safety, and establishes safety requirements and criteria. Section 2 provides the general safety criteria for site related evaluation of external natural and human induced hazards to the nuclear installation. It also establishes requirements relating to the effects of the installation on the region and matters relating to population and emergency planning. Section 3 establishes specific requirements for the characterization of hazards for natural and human induced events. Section 4 establishes specific requirements for site related evaluation of the effects of the installation on the regional environment, the atmosphere, the hydrosphere and biosphere, and the population. Section 5 establishes the requirements for continuous monitoring of natural and human induced hazards throughout the lifetime of the installation. Section 6 establishes requirements for a quality assurance programme for site evaluation.

2. GENERAL REQUIREMENTS

OBJECTIVE

2.1. The main objective in site evaluation for nuclear installations in terms of nuclear safety is to protect the public and the environment from the radiological consequences of radioactive releases due to accidents. Releases due to normal operation should also be considered. In the evaluation of the suitability of a site for a nuclear installation, the following aspects shall be considered:

(a) The effects of external events occurring in the region of the particular site (these events could be of natural origin or human induced);

(b) The characteristics of the site and its environment that could influence the transfer to persons and the environment of radioactive material that has been released;
(c) The population density and population distribution and other characteristics of the external zone in so far as they may affect the possibility of implementing emergency measures and the need to evaluate the risks to individuals and the population.

2.2. If the site evaluation for the three aspects cited indicates that the site is unacceptable and the deficiencies cannot be compensated for by means of design features, measures for site protection or administrative procedures, the site shall be deemed unsuitable.

USES FOR SITE EVALUATION

2.3. In addition to providing the technical basis for the safety analysis report to be submitted to the nuclear regulatory body, the technical information obtained for use in complying with these safety requirements will also be useful in fulfilling the requirements for the environmental impact assessment for radiological hazards.

GENERAL CRITERIA

2.4. Site characteristics that may affect the safety of the nuclear installation shall be investigated and assessed. Characteristics of the natural environment in the region that may be affected by potential radiological impacts in operational states and accident conditions shall be investigated. All these characteristics shall be observed and monitored throughout the lifetime of the installation.

2.5. Proposed sites for nuclear installations shall be examined with regard to the frequency and severity of external natural and human induced events and phenomena that could affect the safety of the installation.

2.6. The foreseeable evolution of natural and human made factors in the region that may have a bearing on safety shall be evaluated for a time period that encompasses the projected lifetime of the nuclear installation. These factors, particularly population growth and population distribution, shall be monitored over the lifetime of the nuclear installation. If necessary,

appropriate measures shall be taken to ensure that the overall risk remains acceptably low. There are three means available to ensure that risks are acceptably low: design features, measures for site protection (e.g. dykes for flood control) and administrative procedures. Design features and protective measures are the preferred means of ensuring that risks are kept acceptably low.

2.7. The hazards associated with external events that are to be considered in the design of the nuclear installation shall be determined. For an external event (or a combination of events) the parameters and the values of those parameters that are used to characterize the hazards should be chosen so that they can be used easily in the design of the installation.

2.8. In the derivation of the hazards associated with external events, consideration should be given to the effects of the combination of these hazards with the ambient conditions (e.g. hydrological, hydrogeological and meteorological conditions).

2.9. In the analysis to determine the suitability of the site, consideration shall be given to additional matters relating to safety such as the storage and transport of input and output materials (uranium ore, UF_6, UO_2, etc.), fresh and spent fuel and radioactive wastes.

2.10. The possible non-radiological impact of the installation, due to chemical or thermal releases, and the potential for explosion and the dispersion of chemical products shall be taken into account in the site evaluation process.

2.11. The potential for interactions between nuclear and non-nuclear effluents, such as the combination of heat or chemicals with radioactive material in liquid effluents, should be considered.

2.12. For each proposed site the potential radiological impacts in operational states and in accident conditions on people in the region, including impacts that could lead to emergency measures, shall be evaluated with due consideration of the relevant factors, including population distribution, dietary habits, use of land and water, and the radiological impacts of any other releases of radioactive material in the region.

2.13. For nuclear power plants, the total nuclear capacity to be installed on the site should be determined as far as possible at the first stages of the siting process. If it is proposed that the installed nuclear capacity be significantly

increased to a level greater than that previously determined to be acceptable, the suitability of the site shall be re-evaluated, as appropriate.

CRITERIA FOR HAZARDS ASSOCIATED WITH EXTERNAL NATURAL AND HUMAN INDUCED EVENTS

2.14. Proposed sites shall be adequately investigated with regard to all the site characteristics that could be significant to safety in external natural and human induced events.

2.15. Possible natural phenomena and human induced situations and activities in the region of a proposed site shall be identified and evaluated according to their significance for the safe operation of the nuclear installation. This evaluation should be used to identify the important natural phenomena or human induced situations and activities in association with which potential hazards are to be investigated.

2.16. Foreseeable significant changes in land use shall be considered, such as the expansion of existing installations and human activities or the construction of high risk installations.

2.17. Prehistorical, historical and instrumentally recorded information and records, as applicable, of the occurrences and severity of important natural phenomena or human induced situations and activities shall be collected for the region and shall be carefully analysed for reliability, accuracy and completeness.

2.18. Appropriate methods shall be adopted for establishing the hazards that are associated with major external phenomena. The methods shall be justified in terms of being up to date and compatible with the characteristics of the region. Special consideration should be given to applicable probabilistic methodologies. It should be noted that probabilistic hazard curves are generally needed to conduct probabilistic safety assessments for external events.

2.19. The size of the region to which a method for establishing the hazards associated with major external phenomena is to be applied shall be large enough to include all the features and areas that could be of significance in the determination of the natural and human induced phenomena under consideration and for the characteristics of the event.

2.20. Major natural and human induced phenomena shall be expressed in terms that can be used as input for deriving the hazards associated with the nuclear installation; that is, appropriate parameters for describing the hazard should be selected or developed.

2.21. In the determination of hazards, site specific data shall be used, unless such data are unobtainable. In this case, data from other regions that are sufficiently relevant to the region of interest may be used in the determination of hazards. Appropriate and acceptable simulation techniques may also be used. In general, data obtained for similar regions and simulation techniques may also be used to augment the site specific data.

CRITERIA FOR DETERMINING THE POTENTIAL EFFECTS OF THE NUCLEAR INSTALLATION IN THE REGION

2.22. In the evaluation of a site to determine its potential radiological impact on the region for operational states and accident conditions that could lead to emergency measures, appropriate estimates shall be made of expected or potential releases of radioactive material, with account taken of the design of the installation and its safety features. These estimates shall be confirmed when the design and its safety features have been confirmed.

2.23. The direct and indirect pathways by which radioactive material released from the nuclear installation could potentially reach and affect people and the environment shall be identified and evaluated; in such an evaluation specific regional and site characteristics shall be taken into account, with special attention paid to the function of the biosphere in the accumulation and transport of radionuclides.

2.24. The site and the design for the nuclear installation shall be examined in conjunction to ensure that the radiological risk to the public and the environment associated with radioactive releases is acceptably low.

2.25. The design of the installation shall be such as to compensate for any unacceptable potential effects of the nuclear installation on the region, or otherwise the site shall be deemed unsuitable.

CRITERIA DERIVED FROM CONSIDERATIONS OF POPULATION AND EMERGENCY PLANNING

2.26. The proposed region shall be studied to evaluate the present and foreseeable future characteristics and the distribution of the population of the region. Such a study shall include the evaluation of present and future uses of land and water in the region and account shall be taken of any special characteristics that may affect the potential consequences of radioactive releases for individuals and the population as a whole.

2.27. In relation to the characteristics and distribution of the population, the combined effects of the site and the installation shall be such that:

(a) For operational states of the installation the radiological exposure of the population remains as low as reasonably achievable and in any case is in compliance with national requirements, with account taken of international recommendations;
(b) The radiological risk to the population associated with accident conditions, including those that could lead to emergency measures being taken, is acceptably low.

2.28. If, after thorough evaluation, it is shown that no appropriate measures can be developed to meet the above mentioned requirements, the site shall be deemed unsuitable for the location of a nuclear installation of the type proposed.

2.29. The external zone for a proposed site shall be established with account taken of the potential for radiological consequences for people and the feasibility of implementing emergency plans, and of any external events or phenomena that may hinder their implementation. Before construction of the plant is started, it shall be confirmed that there will be no insurmountable difficulties in establishing an emergency plan for the external zone before the start of operation of the plant.

3. SPECIFIC REQUIREMENTS FOR EVALUATION OF EXTERNAL EVENTS

EARTHQUAKES AND SURFACE FAULTING[2]

Earthquakes

3.1. The seismological and geological conditions in the region and the engineering geological aspects and geotechnical aspects of the proposed site area shall be evaluated.

3.2. Information on prehistorical, historical and instrumentally recorded earthquakes in the region shall be collected and documented.

3.3. The hazards associated with earthquakes shall be determined by means of seismotectonic evaluation of the region with the use to the greatest possible extent of the information collected.

3.4. Hazards due to earthquake induced ground motion shall be assessed for the site with account taken of the seismotectonic characteristics of the region and specific site conditions. A thorough uncertainty analysis shall be performed as part of the evaluation of seismic hazards.

Surface faulting

3.5. The potential for surface faulting (i.e. the fault capability) shall be assessed for the site. The methods to be used and the investigations to be made shall be sufficiently detailed that a reasonable decision can be reached using the definition of fault capability given in para. 3.6.

3.6. A fault shall be considered capable if, on the basis of geological, geophysical, geodetic or seismological data, one or more of the following conditions applies:

(a) It shows evidence of past movement or movements (significant deformations and/or dislocations) of a recurring nature within such a period that it is reasonable to infer that further movements at or near the surface could

[2] See Refs [2, 3].

occur. In highly active areas, where both earthquake data and geological data consistently reveal short earthquake recurrence intervals, periods of the order of tens of thousands of years may be appropriate for the assessment of capable faults. In less active areas, it is likely that much longer periods may be required.

(b) A structural relationship with a known capable fault has been demonstrated such that movement of the one may cause movement of the other at or near the surface.

(c) The maximum potential earthquake associated with a seismogenic structure is sufficiently large and at such a depth that it is reasonable to infer that, in the geodynamic setting of the site, movement at or near the surface could occur.

3.7. Where reliable evidence shows the existence of a capable fault that has the potential to affect the safety of the nuclear installation, an alternative site shall be considered.

METEOROLOGICAL EVENTS

3.8. The extreme values of meteorological variables and rare meteorological phenomena listed below shall be investigated for the site of any installation. The meteorological and climatological characteristics for the region around the site shall be investigated (see Ref. [4]).

Extreme values of meteorological phenomena

3.9. In order to evaluate their possible extreme values, the following meteorological phenomena shall be documented for an appropriate period of time: wind, precipitation, snow, temperature and storm surges.

3.10. The output of the site evaluation shall be described in a way that is suitable for design purposes for the plant, such as the probability of exceedance values relevant to design parameters. Uncertainties in the data shall be taken into account in this evaluation.

Rare meteorological events

Lightning

3.11. The potential for the occurrence and the frequency and severity of lightning shall be evaluated for the site.

Tornadoes

3.12. The potential for the occurrence of tornadoes in the region of interest shall be assessed on the basis of detailed historical and instrumentally recorded data for the region.

3.13. The hazards associated with tornadoes shall be derived and expressed in terms of parameters such as rotational wind speed, translational wind speed, radius of maximum rotational wind speed, pressure differentials and rate of change of pressure.

3.14. In the assessment of the hazard, missiles that could be associated with tornadoes shall be considered.

Tropical cyclones

3.15. The potential for tropical cyclones in the region of the site shall be evaluated. If this evaluation shows that there is evidence of tropical cyclones or a potential for tropical cyclones, related data shall be collected.

3.16. On the basis of the available data and the appropriate physical models, the hazards associated with tropical cyclones shall be determined in relation to the site. Hazards for tropical cyclones include factors such as extreme wind speed, pressure and precipitation.

3.17. In the assessment of the hazards, missiles that could be associated with tropical cyclones shall be considered.

FLOODING[3]

Floods due to precipitation and other causes

3.18. The region shall be assessed to determine the potential for flooding due to one or more natural causes such as runoff resulting from precipitation or snow melt, high tide, storm surge, seiche and wind waves that may affect the safety of the nuclear installation. If there is a potential for flooding, then all pertinent data, including historical data, both meteorological and hydrological, shall be collected and critically examined.

3.19. A suitable meteorological and hydrological model shall be developed with account taken of the limits on the accuracy and quantity of the data, the length of the historical period over which the data were accumulated, and all known past changes in relevant characteristics of the region.

3.20. The possible combinations of the effects of several causes shall be examined. For example, for coastal sites and sites on estuaries, the potential for flooding by a combination of high tide, wind effects on bodies of water and wave actions, such as those due to cyclones, shall be assessed and taken into account in the hazard model.

3.21. The hazards for the site due to flooding shall be derived from the model.

3.22. The parameters used to characterize the hazards due to flooding shall include the height of the water, the height and period of the waves (if relevant), the warning time for the flood, the duration of the flood and the flow conditions.

3.23. The potential for instability of the coastal area or river channel due to erosion or sedimentation shall be investigated.

Water waves induced by earthquakes or other geological phenomena

3.24. The region shall be evaluated to determine the potential for tsunamis or seiches that could affect the safety of a nuclear installation on the site.

[3] See Ref. [5].

3.25. If there is found to be such a potential, prehistorical and historical data relating to tsunamis or seiches affecting the shore region around the site shall be collected and critically evaluated for their relevance to the evaluation of the site and their reliability.

3.26. On the basis of the available prehistorical and historical data for the region and comparison with similar regions that have been well studied with regard to these phenomena, the frequency of occurrence, magnitude and height of regional tsunamis or seiches shall be estimated and shall be used in determining the hazards associated with tsunamis or seiches, with account taken of any amplification due to the coastal configuration at the site.

3.27. The potential for tsunamis or seiches to be generated by regional offshore seismic events shall be evaluated on the basis of known seismic records and seismotectonic characteristics.

3.28. The hazards associated with tsunamis or seiches shall be derived from known seismic records and seismotectonic characteristics as well as from physical and/or analytical modelling. These include potential draw-down and runup[4] that may result in physical effects on the site.

Floods and waves caused by failure of water control structures

3.29. Information relating to upstream water control structures shall be analysed to determine whether the nuclear installation would be able to withstand the effects resulting from the failure of one or more of the upstream structures.

3.30. If the nuclear installation could safely withstand all the effects of the massive failure of one or more of the upstream structures, then the structures need be examined no further in this regard.

3.31. If a preliminary examination of the nuclear installation indicates that it might not be able to withstand safely all the effects of the massive failure of one or more of the upstream structures, then the hazards associated with the nuclear installation shall be assessed with the inclusion of all such effects; otherwise such upstream structures shall be analysed by means of methods

[4] Draw-down is a falling of the water level at a coastal site. Runup is a sudden surge of water up a beach or a structure.

equivalent to those used in determining the hazards associated with the nuclear installation to show that the structures could survive the event concerned.

3.32. The possibility of storage of water as a result of the temporary blockage of rivers upstream or downstream (e.g. caused by landslides or ice) so as to cause flooding and associated phenomena at the proposed site shall be examined.

GEOTECHNICAL HAZARDS[5]

Slope instability

3.33. The site and its vicinity shall be evaluated to determine the potential for slope instability (such as land and rock slides and snow avalanches) that could affect the safety of the nuclear installation.

3.34. If there is found to be a potential for slope instability that could affect the safety of the nuclear installation, the hazard shall be evaluated by using parameters and values for the site specific ground motion.

Collapse, subsidence or uplift of the site surface

3.35. Geological maps and other appropriate information for the region shall be examined for the existence of natural features such as caverns, karstic formations and human made features such as mines, water wells and oil wells. The potential for collapse, subsidence or uplift of the site surface shall be evaluated.

3.36. If the evaluation shows that there is a potential for collapse, subsidence or uplift of the surface that could affect the safety of the nuclear installation, practicable engineering solutions shall be provided or otherwise the site shall be deemed unsuitable.

3.37. If there do seem to be practicable engineering solutions available, a detailed description of subsurface conditions obtained by reliable methods of investigation shall be developed for the purposes of determination of the hazards.

[5] See Ref. [2].

Soil liquefaction

3.38. The potential for liquefaction of the subsurface materials of the proposed site shall be evaluated by using parameters and values for the site specific ground motion.

3.39. The evaluation shall include the use of accepted methods of soil investigation and analytical methods to determine the hazards.

3.40. If the potential for soil liquefaction is found to be unacceptable, the site shall be deemed unsuitable unless practicable engineering solutions are demonstrated to be available.

Behaviour of foundation materials

3.41. The geotechnical characteristics of the subsurface materials, including the uncertainties in them, shall be investigated and a soil profile for the site in a form suitable for design purposes shall be determined.

3.42. The stability of the foundation material under static and seismic loading shall be assessed.

3.43. The groundwater regime and the chemical properties of the groundwater shall be studied.

EXTERNAL HUMAN INDUCED EVENTS[6,7]

Aircraft crashes

3.44. The potential for aircraft crashes on the site shall be assessed with account taken, to the extent practicable, of characteristics of future air traffic and aircraft.

[6] Wilful actions that may potentially affect the site area are excluded from consideration here.

[7] See Ref. [6].

3.45. If the assessment shows that there is a potential for an aircraft crash on the site that could affect the safety of the installation, then an assessment of the hazards shall be made.

3.46. The hazards associated with an aircraft crash to be considered shall include impact, fire and explosions.

3.47. If the assessment indicates that the hazards are unacceptable and if no practicable solutions are available, then the site shall be deemed unsuitable.

Chemical explosions

3.48. Activities in the region that involve the handling, processing, transport and storage of chemicals having a potential for explosions or for the production of gas clouds capable of deflagration or detonation shall be identified.

3.49. Hazards associated with chemical explosions shall be expressed in terms of overpressure and toxicity (if applicable), with account taken of the effect of distance.

3.50. A site shall be considered unsuitable if such activities take place in its vicinity and there are no practicable solutions available.

Other important human induced events

3.51. The region shall be investigated for installations (including installations within the site boundary) in which flammable, explosive, asphyxiant, toxic, corrosive or radioactive materials are stored, processed, transported and otherwise dealt with that, if released under normal or accident conditions, could jeopardize the safety of the installation. This investigation shall also include installations that may give rise to missiles of any type that could affect the safety of the nuclear installation. The potential effects of electromagnetic interference, eddy currents in the ground and the clogging of air or water inlets by debris shall also be evaluated. If the effects of such phenomena and occurrences would produce an unacceptable hazard and if no practicable solution is available, the site shall be deemed unsuitable.

OTHER IMPORTANT CONSIDERATIONS[8]

3.52. Historical data concerning phenomena that have the potential to give rise to adverse effects on the safety of the nuclear installation, such as volcanism, sand storms, severe precipitation, snow, ice, hail, and subsurface freezing of subcooled water (frazil), shall be collected and assessed. If the potential is confirmed, the hazard shall be assessed and design bases for these events shall be derived.

3.53. In the design of systems for long term heat removal from the core, site related parameters, such as the following, should be considered:

(a) Air temperature and humidity;
(b) Water temperatures;
(c) Available flow of water, minimum water level and the period of time for which safety related sources of cooling water are at a minimum level, with account taken of the potential for failure of water control structures.

3.54. Potential natural and human induced events that could cause a loss of function of systems required for the long term removal of heat from the core shall be identified, such as the blockage or diversion of a river, the depletion of a reservoir, an excessive amount of marine organisms, the blockage of a reservoir or cooling tower by freezing or the formation of ice, ship collisions, oil spills and fires. If the probabilities and consequences of such events cannot be reduced to acceptable levels, then the hazards for the nuclear installation associated with such events shall be established.

3.55. If the hazards for the nuclear installation are unacceptable and no practicable solution is available, the site shall be deemed unsuitable.

[8] See Ref. [7].

4. SITE CHARACTERISTICS AND THE POTENTIAL EFFECTS OF THE NUCLEAR INSTALLATION IN THE REGION[9]

ATMOSPHERIC DISPERSION OF RADIOACTIVE MATERIAL

4.1. A meteorological description of the region shall be developed, including descriptions of the basic meteorological parameters, regional orography and phenomena such as wind speed and direction, air temperature, precipitation, humidity, atmospheric stability parameters, and prolonged inversions.

4.2. A programme for meteorological measurements shall be prepared and carried out at or near the site with the use of instrumentation capable of measuring and recording the main meteorological parameters at appropriate elevations and locations. Data from at least one full year shall be collected, together with any other relevant data that may be available from other sources.

4.3. On the basis of the data obtained from the investigation of the region, the atmospheric dispersion of radioactive material released shall be assessed with the use of appropriate models. These models shall include all significant site specific and regional topographic features and characteristics of the installation that may affect atmospheric dispersion.

DISPERSION OF RADIOACTIVE MATERIAL THROUGH SURFACE WATER

4.4. A description of the surface hydrological characteristics of the region shall be developed, including descriptions of the main characteristics of water bodies, both natural and artificial, the major structures for water control, the locations of water intake structures and information on water use in the region.

4.5. A programme of investigation and measurements of the surface hydrology shall be carried out to determine to the extent necessary the dilution and dispersion characteristics for water bodies, the reconcentration ability of sediments and biota, and the determination of transfer mechanisms of radionuclides in the hydrosphere and of exposure pathways.

[9] See Ref. [8].

4.6. An assessment of the potential impact of the contamination of surface water on the population shall be performed by using the collected data and information in a suitable model.

DISPERSION OF RADIOACTIVE MATERIAL THROUGH GROUNDWATER

4.7. A description of the groundwater hydrology of the region shall be developed, including descriptions of the main characteristics of the water bearing formations, their interaction with surface waters and data on the uses of groundwater in the region.

4.8. A programme of hydrogeological investigations shall be carried out to permit the assessment of radionuclide movement in hydrogeological units. This programme should include investigations of the migration and retention characteristics of the soils, the dilution and dispersion characteristics of the aquifers, and the physical and physicochemical properties of underground materials, mainly related to transfer mechanisms of radionuclides in groundwater and their exposure pathways.

4.9. An assessment of the potential impact of the contamination of groundwater on the population shall be performed by using the data and information collected in a suitable model.

POPULATION DISTRIBUTION

4.10. The distribution of the population within the region shall be determined.

4.11. In particular, information on existing and projected population distributions in the region, including resident populations and to the extent possible transient populations, shall be collected and kept up to date over the lifetime of the installation. The radius within which data are to be collected should be chosen on the basis of national practices, with account taken of special situations. Special attention shall be paid to the population living in the immediate vicinity of the installation, to densely populated areas and population centres in the region, and to residential institutions such as schools, hospitals and prisons.

4.12. The most recent census data for the region, or information obtained by extrapolation of the most recent census data, shall be used in obtaining the population distribution. In the absence of reliable data, a special study shall be carried out.

4.13. The data shall be analysed to give the population distribution in terms of the direction and distance from the plant. An evaluation shall be performed of the potential radiological impacts of normal discharges and accidental releases of radioactive material, including reasonable consideration of releases due to severe accidents, with the use of site specific parameters as appropriate.

USES OF LAND AND WATER IN THE REGION

4.14. The uses of land and water shall be characterized in order to assess the potential effects of the nuclear installation in the region and particularly for the purposes of preparing emergency plans. The investigation should cover land and water bodies that may be used by the population or may serve as a habitat for organisms in the food chain.

AMBIENT RADIOACTIVITY

4.15. Before commissioning of the nuclear installation the ambient radioactivity of the atmosphere, hydrosphere, lithosphere and biota in the region shall be assessed so as to be able to determine the effects of the installation. The data obtained are intended for use as a baseline in future investigations.

5. MONITORING OF HAZARDS

5.1. The characteristics of the natural and human induced hazards as well as the demographic, meteorological and hydrological conditions of relevance to the nuclear installation shall be monitored over the lifetime of the nuclear installation. This monitoring shall be commenced no later than the start of construction and shall be continued up until decommissioning. All the hazards and conditions that are considered in this Safety Requirements publication and that are pertinent to the licensing and safe operation of the installation shall be monitored.

6. QUALITY ASSURANCE[10]

6.1. An adequate quality assurance programme shall be established to control the effectiveness of the execution of the site investigations and assessments and engineering activities performed in the different stages of the site evaluation for the nuclear installation.

6.2. The quality assurance programme shall cover the organization, planning, work control, personnel qualification and training, verification and documentation for the activities to ensure that the required quality of the work is achieved.

6.3. The quality assurance programme is a part of the overall quality assurance programme for the nuclear installation. However, since activities for site investigation are normally initiated long before the establishment of a nuclear project, the quality assurance programme should be established at the earliest possible time consistent with its application in the conduct of site evaluation activities for the nuclear installation.

6.4. The results of the activities for site investigation should be compiled in a report that documents the results of all in situ work, laboratory tests and geotechnical analyses and evaluations.

6.5. The results of studies and investigations shall be documented in sufficient detail to permit an independent review.

6.6. A quality assurance programme shall be implemented for all activities that may influence safety or the derivation of parameters for the design basis for the site. The quality assurance programme may be graded in accordance with the importance to safety of the individual siting activity under consideration.

6.7. The process of establishing site related parameters and evaluations involves technical and engineering analyses and judgements that require extensive experience and knowledge. In many cases the parameters and analyses may not lend themselves to direct verification by inspections, tests or other techniques that can be precisely defined and controlled. These

[10] See Ref. [9].

evaluations shall be reviewed and verified by individuals or groups (e.g. by peer review) who are separate from those who did the work.

6.8. In accordance with the importance of engineering judgement and expertise in geotechnical engineering, the feedback of experience is an important aspect. For the assessment of matters such as the liquefaction potential, the stability of slopes and the safety in general of earth and of buried structures, information from the feedback of experience of failures in comparable situations shall be documented and analysed in order to be able to provide evidence that similar failures will not occur.

6.9. Records shall be kept of the work carried out in the activities for site evaluation for the nuclear installation.

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GLOSSARY

design basis external events. The external event(s) or combination(s) of external events considered in the design basis of all or any part of a facility.

external events. Events unconnected with the operation of a facility or activity which could have an effect on the safety of the facility or activity.

external zone. The area immediately surrounding a proposed site area in which population distribution and density, and land and water uses, are considered with respect to their effects on the possible implementation of emergency measures.

site area. A geographical area that contains an authorized facility, and within which the management of the authorized facility may directly initiate emergency actions.

site personnel. All persons working in the site area of an authorized facility, either permanently or temporarily.

siting. The process of selecting a suitable site for a facility, including appropriate assessment and definition of the related design bases.

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