

# IAEA Safety Standards

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## Site Evaluation for Nuclear Installations

### Specific Safety Requirements DS484

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# 1. INTRODUCTION

## BACKGROUND

1.1. This Safety Requirements publication supersedes Site Evaluation for Nuclear Installations which was issued in 2016 as IAEA Safety Standards Series No. NS-R-3 (Rev. 1)<sup>1</sup>. This publication takes into account and incorporates developments related to site evaluations for nuclear installations since the publication of IAEA Safety Standards Series No. NS-R-3 in 2003 and the partially revised publication NS-R-3 (Rev. 1) in 2016, which addressed overarching issues highlighted after the Fukushima Daiichi accident. It applies the IAEA Safety Standards Series No. SF-1, Fundamental Safety Principles [1]. Requirements for site evaluation are intended to contribute to the adequate protection of site personnel and the public and protection of the environment from harmful 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 Member States.

1.2. This Safety Requirements publication establishes requirements and provides criteria for ensuring safety in site evaluation for nuclear installations. The related Safety Guides on site evaluation 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 appropriate requirements and criteria for:

- (a) Defining the information to be used in the site evaluation process;
- (b) Evaluating a site to ensure that the site related hazardous phenomena and characteristics are adequately taken into account, so that the site related hazards are properly assessed and that the corresponding site specific design parameters are appropriate;
- (c) Analysing the characteristics of the population and the area surrounding the site aimed to determine if there would be significant difficulties for emergency response actions effectively.

The criteria described above are to be applied:

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<sup>1</sup> INTERNATIONAL ATOMIC ENERGY AGENCY, Site Evaluation for Nuclear Installations, IAEA Safety Standards Series No. NS-R-3 (Rev. 1), IAEA Vienna, (2016).

- i. to identify the natural and human induced events external to the installation that could challenge the safety of the nuclear installation
- ii. to assess the site and site–installation interactions in operational states and accident conditions, over the projected lifetime of the installation, including those interactions that require guaranteed proper implementation of emergency response plans.

1.4. This publication is intended for use by regulatory bodies responsible for establishing regulatory requirements, and for operating organizations directly responsible for conducting site evaluation of nuclear installations.

## SCOPE

1.5. This Safety Requirements publication addresses a broad range of nuclear installations as defined in the IAEA Safety Glossary [2].

1.6. This Safety Requirements publication covers site evaluation for both new and existing nuclear installations. Requirements for hazard evaluation are applicable to both categories.

1.7. The site area is the geographical area that contains an authorized facility, authorized activity or source, and within which the management of the authorized facility or authorized activity or first responders may directly initiate emergency response, as defined in IAEA Safety Standards Series No. GSR Part 7, Preparedness and Response for a Nuclear or Radiological Emergency [3]. This is typically the area within the security perimeter fence or other designated property marker.

1.8. The external human induced events considered in this Safety Requirements publication are of accidental origin. Considerations relating to the physical protection of the installation against wilful actions by third parties are outside its scope although they may bear significant safety implications for site evaluation.

1.9. The site selection process, also called ‘siting processes’, is divided into two stages<sup>2</sup>:

- a) Site survey when potential sites are identified on the basis of existing data
- b) Site Selection aim to arrive at the ‘preferred candidate site(s)’. In this second stage the candidate sites are assessed by screening and ranking.

The aim of the second stage is to identify suitable sites and to select list of candidate site(s). In this second stage the candidate sites are assessed by screening and ranking to arrive at the ‘preferred candidate sites’. Site suitability shall be confirmed during the site evaluation process. The site evaluation process starts with the second stage of the siting process,

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<sup>2</sup> More details about the siting and site evaluation process are presented in the IAEA Safety Standards Series No. SSG-35, Site Survey and Site Selection for Nuclear Installations.



following the site survey and shall continue throughout the entire lifetime of the site. During the operation stage of the nuclear installation, site evaluation continues with confirmatory and monitoring activities of the design basis parameters as well as any full and comprehensive re-evaluation process as required by the periodic safety reviews.

1.10. This publication addresses the evaluation of those site related factors that have to be taken into account to ensure that the site–installation interactions do not constitute an unacceptable risk to individuals, the population or the environment over the lifetime of the installation. The non-radiological aspects of the environmental impact of the site and the installation are not explicitly covered in this publication.

## STRUCTURE

1.11. This Safety Requirements publication follows the relationship between safety principles and safety objectives in establishing safety requirements and criteria to be used during site evaluation for nuclear installations.

1.12. Section 2 of this publication describes the safety principles and concepts applicable to site evaluation. Section 3 describes the application of the management system for site evaluation. Section 4 establishes the general requirements that are applicable to all types of nuclear installations. Section 5 establishes specific requirements for the evaluation of natural and human induced external hazards and phenomena. Section 6 establishes specific requirements for site related evaluation of the effects of the installation on the regional environment, the atmosphere, the hydrosphere and the biosphere, and on the population. Section 7 establishes requirements for monitoring and periodic re-evaluation of natural and human induced hazards and site conditions throughout the lifetime of the installation.

## 2. SAFETY PRINCIPLES AND CONCEPTS

2.1. SF-1 [1] establishes one fundamental safety objective and ten safety principles that provide the basis for requirements and measures for the protection of people and the environment against the harmful effects of ionizing radiation and for the safety of facilities and activities that give rise to radiation risk.

2.2. The fundamental safety objective is to protect people and the environment from harmful effects of ionizing radiation. Paragraph 2.1 of SF-1[1] states that:

“This fundamental safety objective of protecting people - individually and collectively - and the environment has to be achieved without unduly limiting the operation of facilities or the conduct of activities that give rise to radiation risk. To ensure that nuclear installations are

operated and activities are conducted so as to meet the highest standards of safety that can reasonably be achieved, measures have to be taken:

- (a) To control the radiation exposure of people and the release of radioactive material to the environment;
- (b) To restrict the likelihood of events that might lead to a loss of control over a nuclear reactor core, nuclear chain reaction, radioactive source or any other source of radiation;
- (c) To mitigate the consequences of such events if they were to occur.”

2.3. Paragraph 2.2 of SF-1 [1] states that:

“The fundamental safety objective applies for all facilities and activities and for all stages over the lifetime of a facility or radiation source, including planning, siting, design, manufacturing, construction, commissioning, and operation, as well as decommissioning and closure. This includes the associated transport of radioactive material and management of radioactive waste.”

2.4. This Safety Requirements publication establishes requirements that apply for implementation of safety principles 8 and 9 [1] as these two principles are the most relevant for consideration in site evaluation for nuclear installations. In this regard:

- (a) Principle 8 states that:

“The primary means of preventing and mitigating the consequences of accidents is ‘defence in depth’. Defence in depth is implemented primarily through the combination of a number of consecutive and independent levels of protection that would have to fail before harmful effects could be caused to people or to the environment. One element is related to adequate site selection and the incorporation of good design and engineering features providing safety margins, diversity and redundancy.”

- (b) To address Principle 9, the site evaluation process of a nuclear installation shall identify the reasonably foreseeable external hazards, including those of very low probability. In addition, in order to assess the feasibility of implementation of emergency response actions in the region, the site evaluation process shall identify the site characteristics that can affect the interactions between the nuclear installation, the environment and the population.

### **3. APPLICATION OF THE MANAGEMENT SYSTEM FOR SITE EVALUATION**

#### **Requirement 1: Application of the management system for site evaluation**

**Site evaluation shall be conducted in a comprehensive, systematic, planned and documented manner and included in the management system.**

3.1. A management system in compliance with IAEA Safety Standards Series No. GSR Part 2, Leadership and Management for Safety [4] shall be established covering the organization, planning, work control, personnel qualification and training, verification and documentation for activities to ensure that the required quality of the work is achieved. The management system shall be established at the earliest possible time to conduct site evaluation activities for the nuclear installation.

3.2. The management system shall ensure the quality and the control of the effective engineering activities performed in each stages of the site evaluation for the nuclear installation.

3.3. The site evaluation process shall include proper quality assurance arrangements covering those activities that can influence nuclear safety or the derivation of parameters for the design basis for the site. The quality assurance arrangements shall be consistent with regulatory requirements and shall be graded in accordance with the importance to safety of the individual siting and site evaluation activity under consideration.

3.4. For each activity of the site evaluation process, including inspection, testing, verification and/or validation, the acceptance criteria and the responsibilities for carrying out these activities shall be specified.

3.5. The data collected during the site evaluation process shall be kept and the results of studies and investigations from the site evaluation process shall be documented in sufficient detail to permit an independent review. The assessments of site related external natural and human induced hazards shall be independently reviewed.

#### **4. GENERAL REQUIREMENTS FOR SITE EVALUATION**

This section contains general requirements that are applicable to the site evaluation process for all types of nuclear installations.

##### **Requirement 2: Site safety objectives in site evaluation for nuclear installations**

**The main safety objective in site evaluation for nuclear installations shall be to characterize the natural and man-made hazards that may challenge the safety of the nuclear installation and to provide adequate input for demonstration of protection of**

**the public and the environment from the radiological consequences of radioactive releases due to accidents.**

4.1. The site evaluation process shall contain detailed acceptance criteria which are derived from safety objectives (see para. 2.2 and [1]). These criteria shall together contribute to demonstration of achieving the site safety objectives which address all stages of the project lifetime (siting, design, construction, commissioning, operation and decommissioning) as well as emergency preparedness and additional matters as appropriate.

4.2. Site safety objectives shall be defined with reference to both short and long term radiological impact to people and the environment. The objectives shall be expressed in terms associated with radiological consequences for individuals, public and the environment.

### **Requirement 3: Scope of the site evaluation for nuclear installations**

**The scope shall consider site related factors and site–installation interaction factors relating to operational states and accidents, including those that could warrant emergency response actions and external natural and human induced events external to the installation that could affect the safety of the nuclear installation.**

4.3. The scope covers all external hazards and site specific parameters relevant for nuclear installations safety, with the use of a graded approach on the basis of the radiation risk that they pose to people and the environment. The main principle of the graded approach is stated in SF-1[1] and defined in [2].

#### **USE OF THE GRADED APPROACH**

4.4. The graded approach is aimed to scale down the application of safety requirements for analysis, evaluation, and documentation considering the potential hazards associated with operating nuclear facilities other than nuclear power plants.

4.5. The level of details needed in an evaluation to meet the requirements established in this publication shall be commensurate with the risk associated with the facilities and its site and vary according to the type of installation located at the site. Nuclear power plants will generally require the highest level of details.

4.6. The scope and depth of the site evaluation process necessary to support the installation's safety cases shall be determined. A site can be screened out from following a formal site evaluation process if no unacceptable radiological consequences would be likely for workers or for the public or for the environment.

4.7. For nuclear installations other than nuclear power plants where a graded approach is applied to site safety evaluation, the following shall be taken into consideration:

- (a) The amount, type and status of the radioactive inventory at the site (e.g. whether solid or fluid, processed or stored);
- (b) The intrinsic hazard associated with the physical processes that take place at the installation;
- (c) The thermal power of in case of research reactors;
- (d) The distribution and/or location of radioactive sources in the installation;
- (e) The changing nature of the configuration and layout for installations designed for experiments;
- (f) The need for active systems and/or operator actions for the prevention of accidents and for mitigation of the consequences of accidents;
- (g) The potential for on-site and off-site consequences.

#### **Requirement 4: Site suitability**

**The site suitability shall be assessed in the early stage of the site evaluation and shall be confirmed for the lifetime of the planned installation.**

4.8. In the assessment of the suitability of a site for a nuclear installation, the following aspects shall be addressed:

- (a) The effects of external events occurring in the region of a particular site (the external events can be of a natural origin or human induced);
- (b) The characteristics of the site and its environment that can influence the transfer to persons and to the environment of radioactive material that has been released;
- (c) The population density, population distribution and other characteristics of the external region in so far as they can affect the feasibility of planning to implement emergency response actions effectively as required in GSR Part 7 [3] and the need to evaluate the risk to individuals and to the population.

4.9. The site shall be deemed unsuitable for the location of the nuclear installations if the site evaluation for the three aspects cited above indicate that site is unacceptable and the safety deficiencies cannot be compensated for by means of a proper balance of site protection measures, design features of the installation, and administrative procedures, either upon initial analysis or after subsequent reviews.

4.10. Site suitability shall be assessed on the basis of relevant updated data and methodologies and consistent with planned operations at the site. Conservative criteria can be developed in relation to site specific scenarios; in such a case, their consistency with the generic criteria for site suitability shall be demonstrated.

4.11. A decision regarding site suitability shall be based on the installation's characteristics, the amount and nature of potential releases and their impact on the environment.

4.12. For nuclear power plants, the total nuclear capacity to be installed at the site shall be determined at the first stages of the siting process. If it is determined or anticipated that the installed nuclear capacity and inventory or its impact have been increased to a level significantly greater than that previously determined to be acceptable, the site shall be re-evaluated considering the higher capacity or impact.

4.13. The overall evaluation of site suitability shall assess conditions for safe operation of the installation. Site related parameters such as cooling water availability or extreme environmental conditions shall also be addressed in their potential role of affecting the safe, continuous operation of the installation.

#### **Requirement 5: Site and regional characteristics**

**The site and regional area shall be investigated with regard to the characteristics that can impact nuclear safety and potential radiological impact of nuclear installation on population and environment.**

4.14. Natural phenomena as well as human activities in the site region with potential to induce hazards at the site that may affect the safety of the nuclear installation shall be identified and evaluated, according to their safety significance.

4.15. Characteristics of the natural environment in the region that can be affected by the potential radiological impact of the installation in all operational states and accident conditions throughout its lifetime shall be investigated and assessed.

4.16. The size of the region to be investigated, also called the geographic area of interest, shall be defined for each of the external natural phenomena and human induced situations and activities under evaluation and it shall be large enough to include those features, sources and areas that can be of significance in the determination of the hazardous phenomena under consideration and for the characteristics of the events. The correlation between event magnitude and distance from the source to the site shall be given priority in the definition of the size of the region to be investigated. For some specific external natural phenomena, such

as tsunamis and volcanic manifestations, adequate regions shall be identified and considered for the potential hazards that can affect the safety of the nuclear installation.

4.17. The region shall be studied to evaluate the present and foreseeable future characteristics that can have an impact on nuclear safety. This includes distribution of the population in the region, the present and future use of land and water, the development of existing installations and human activities or the construction of facilities that can impact on the safety of the installation and the feasibility of planning to implement emergency response actions effectively.

#### **Requirement 6: Identification of the site specific hazards**

**Potential hazards resulting from external natural phenomena and human induced events and activities which can occur in the region of the site shall be identified through a screening process. External hazards not screened out shall be evaluated and selected for design basis or re-evaluation purposes according to their significance to the safety of the installation.**

4.18. The screening process and associated criteria used in screening of the site specific hazards shall comply with the site safety objectives and shall be properly justified and documented.

4.19. Events of high severity but low probability<sup>3</sup> that could contribute to the overall risk shall be included in the site evaluation process. Events of low severity but high probability that could contribute to the overall risk shall also be included in the site evaluation process.

4.20. With respect to screening out events, it shall be ensured that all effects (e.g., loaded cases) resulting from these events are bounded. Events may be screened out through enveloping within a set of events.

#### **Requirement 7: Evaluation of external natural and human induced hazards**

**The impact of external natural and human induced hazards on the safety of the nuclear installation shall be evaluated taking into account site specific conditions over the lifetime of the installation.**

4.21. Proposed sites for a nuclear installation shall be evaluated with regard to the frequency and severity of external natural and human induced events, and the potential combinations of such events, that could affect the safety of the installation.

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<sup>3</sup> For example the low probability could be defined as the annual probability smaller than the threshold used for defining the hazard severity for design (e.g.  $10^{-4}$ ) but higher than that threshold for CDF/LERF (e.g.  $10^{-5}/10^{-6}$ ).

4.22. Information on frequency and severity derived from the characterization of the hazards resulting from external events shall be used in establishing the site specific design parameters for the nuclear installation. Adequate account shall be taken of uncertainties in the design basis hazard level.

4.23. Appropriate methods, supported by numerical models when needed, shall be used to derive hazards characteristics relevant for site evaluation and design of the facility. A thorough uncertainty analysis of the method and input data shall be performed as part of the evaluation.”

4.24. The decision for using probabilistic or deterministic methodologies in hazard evaluation shall be based on the nature of the hazard, availability of data and the applicable requirements for safety assessment. Special consideration shall be given to applicable probabilistic methodologies since external events hazard curves are needed as input for probabilistic safety assessment against external hazards.

4.25. Probabilistic hazard curves shall be developed with reference to the specific application (e.g. design, margin evaluation, probabilistic safety assessment, hazard monitoring, and emergency planning).

4.26. Hazard assessments shall address the possibility that external events can occur in combination, simultaneously or within short time frames. Interrelationships and causality between external events as well as modifications of site conditions in time shall be evaluated.

4.27. Natural and human induced phenomena shall be analysed and results 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 severity of the hazard effects shall be selected or developed.

#### **Requirement 8: Site protection measures**

**The need for site protection measures shall be evaluated if the projected design of the nuclear installation is not able to safely withstand either the impact of external natural and human induced hazards defined as design basis during the early site evaluation stage or resulting from the re-evaluation of the external natural and human induced hazards during the operating lifetime of the nuclear installation.**

4.28. The need for protection of the site against the effects of specific phenomena of external natural and human induced hazards (e.g. flooding, explosions, etc.), shall be evaluated considering adequate safety margins.



4.29. The availability of adequate engineering solutions for implementing site protection measures shall be evaluated and if such engineering solutions are not available, the site shall be deemed unsuitable.

4.30. If either as a result of the evaluation performed according to Requirement 7 during the early site evaluation stage or later, during the operating lifetime as a result of periodic safety site re-evaluation, site protection measures are required to be implemented, conservative assumptions shall be taken in order to account for the uncertainties in the evaluation of extreme values of external natural and human induced hazards. Also the site protection measures shall be classified, designed, built, maintained and operated as structures, systems and components important to safety.

**Requirement 9: Site evaluation for multiple installations at the same site and co-located sites.**

**The site evaluation shall consider the potential of external natural and human induced hazards that can affect multiple installations at the same site as well as co-located sites.**

4.31. Occurrences of external natural and human induced hazards and their credible combinations, which are able to challenge the safety of multi-unit or co-located sites and to generate disruptions of infrastructure affecting communications, transportation and utilities, shall be considered. The hazards originated from one installation of multi-installation site on other installations located at the same site shall be assessed.

**Requirement 10: Change of hazards and site characteristics with time**

**The external hazards and the site characteristics shall be assessed regarding their potential for changing with time and the impact of these changes to the design basis and the feasibility of planning to implement emergency response actions effectively. If necessary, the estimate of changes during the installation operating lifetime shall be incorporated, taking due consideration of the uncertainties involved in these assessments.**

4.32. The natural and human induced hazards affecting the safety of nuclear installations as well as the site characteristics can change over time as a result of various causes or their combinations, and the potential consequences of such changes shall be duly assessed for the planned operating lifetime of the installation.

4.33. Taking due account of the uncertainties in the projections of climatic variability and change, appropriate safety margins shall be included in the related design envelope of the nuclear installation.

**Requirement 11: Special considerations for the ultimate heat sink for nuclear installations requiring an ultimate heat sink**

**The evaluation of site specific external and human induced hazards shall consider hazards that can impact the availability and reliability of the ultimate heat sink for nuclear installations requiring an ultimate heat sink.**

4.34. As appropriate for the ultimate heat sink under consideration, the following data shall be evaluated:

- a) Ice, frazil ice; fire
- b) oil and chemical spills;
- c) Air temperature, humidity;
- d) Water temperatures;
- e) Water quality characteristics including turbidity, suspended solids, and chemical and biochemical changes (natural or human induced);
- f) Available and sustainable water flow (for a river), minimum and maximum 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.

4.35. Potential natural and human induced events that can cause a loss of function of systems required for the long term heat removal shall be identified and evaluated.

**Requirement 12: Potential effects of the nuclear installation on the public and the environment**

**In site evaluation, to determine the potential radiological impact of the nuclear installation on the region for operational states and accidents that can warrant emergency response actions, 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.**

4.36. The potential effects of the nuclear installation on the public and the environment shall be evaluated considering co-located installations (e.g. ‘a multiple installation site’), their postulated accident scenarios (including resulting source terms), feasibility of planning and infrastructures, to implement emergency response actions effectively at the site and in the

region. These estimates shall be confirmed when the design and its safety features have been established.

4.37. The potential effects of nuclear installations located at nearby sites (e.g., ‘multiple sites’) shall be evaluated based on their correlation in relation to the size of the area affected by the identified hazard scenarios.

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

**Requirement 13: Feasibility of planning to implement emergency response actions effectively**

**The feasibility of planning to implement emergency response actions effectively on the site and in the external region shall be evaluated taking account of the site characteristics, characteristics of the surrounding area and any external events that could significantly hinder the establishment of complete emergency arrangements prior to operation.**

4.39. The requirements for site evaluation apply also to the infrastructure in and other characteristics of the external region where emergency response actions may be warranted.

4.40. An assessment shall be made of the feasibility of development and implementation of an emergency plan for taking emergency response actions effectively as required in GSR Part 7 [3]. The on-site and co-located installations shall be considered in the assessment, with special emphasis on nuclear installations that can experience concurrent accidents.

4.41. A causal relationship between external events, site and infrastructure conditions shall be considered in evaluating the feasibility of planning to implement emergency response actions effectively.

4.42. In the site evaluation, it shall be demonstrated that the radiological risk to the population associated with accident conditions, including those that could warrant emergency response actions being taken in the external region, is compliant with the site safety objectives.

**Requirement 14: Data collection in site evaluation for nuclear installations**

**The necessary data needed to perform an assessment of external natural and human induced hazards and to assess both the impact of the environment on the installation safety and the impact of the installation on the public and the environment shall be collected.**

4.43. Data regarding external natural and human induced hazards with the potential to give rise to adverse effects on the safety of the nuclear installation over the lifetime of the installation shall be collected. Data shall be confirmed to be spatially and temporally pertinent to the site with preference given to site-specific data.

4.44. The extent, objectives and scope of the data collection process shall be defined based on site safety objectives graded to the hazard posed by the installation to the public and the environment.

4.45. The data collection process shall address the following as a minimum:

- (a) External natural and human induced hazards information: sources, propagation, potential effects on the installation and workers, the public and the environment;
- (b) Information describing site and regional environmental conditions;
- (c) Characteristics of the proposed engineering and administrative protective site features and mitigation measures;
- (d) Characteristics of the potential impact of the installations on the public and the environment as a result of both normal operations as well as radiological accidents ;
- (e) Information required for the establishment of emergency planning on-site and off-site in any environmental and installations conditions;
- (f) Conditions for access to the site and circulation at the site
- (g) Characteristics of site hazard monitoring, hazard alerts and periodic site re-evaluation conditions.

4.46. The data shall be reviewed periodically, and/or as needed, as part of a site evaluation review within the framework of periodic safety review, for example, to address evolutions in data gathering, analysis, storage, and use and to confirm that the data remain pertinent to the site in the face of evolving hazards.

4.47. The data collection, analysis and processing methods for the site investigations shall be sufficiently detailed to support safety decisions. The documentation shall be sufficiently detailed to permit an independent review.

4.48. The details of information collected shall be appropriate to the distance from (and potential impact on) the site.

4.49. Prehistoric, historical and instrumentally recorded information and records of the occurrences and severity of important natural phenomena shall be obtained, if available, as appropriate for the hazard to be evaluated and analysed for reliability, accuracy, temporal pertinence and completeness.

4.50. The sources of uncertainties related to data collection shall be documented.

## 5. SPECIFIC REQUIREMENTS FOR EVALUATION OF EXTERNAL EVENTS

This section addresses requirements for the evaluation of external events. They are to be applied as appropriate for the type of installation as well as the specific site under consideration. A justification for why a specific requirement is not included in the site evaluation shall be provided.

### SEISMIC HAZARDS

#### **Requirement 15: Fault displacement hazard evaluation**

**Faults within a certain size range and within a certain distance of the installation critical to site safety shall be evaluated to identify the capability of the fault and potential challenge to the site safety in terms of ground motion and/or fault displacement hazard.**

5.1. Fault capability<sup>4</sup> shall be identified and evaluated. The evaluation shall consider the fault characteristics in the vicinity of the site. The methods to be used and the investigations to be made shall be sufficiently detailed to support safety related decisions.

5.2. The fault displacement hazard shall be evaluated to provide the input needed for the design or upgrading of the structures, systems and components of the nuclear installation, as well as the safety analyses performed during the lifetime of the installation.

5.3. If a capable fault is identified in the vicinity of the site of an existing nuclear installation, the site shall be deemed unsuitable if the safety of the site cannot be demonstrated.

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<sup>4</sup> A fault is considered capable if, on the basis of geological, geophysical, geodetic or seismological data (including palaeoseismological and geomorphological data), one or more of the following conditions applies:

- (a) It shows evidence of past movement or movements (significant surface 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 occur. In highly active areas, where both earthquake data and geological data consistently and/or exclusively 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 will be required.
- (b) A structural relationship with a known capable fault has been demonstrated such that movement of one could 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.

## **Requirement 16: Ground motion hazard evaluation**

**A ground motion hazard evaluation shall be conducted to provide the input needed for the design or seismic safety upgrading of the structures, systems and components of the nuclear installation, as well as for performing the deterministic and/or probabilistic safety analyses necessary during the lifetime of the installation.**

5.4. Hazards due to earthquake induced ground motion shall be assessed for the site with account taken of the seismic sources characteristics of the regional seismotectonics, seismic waves propagation characteristics and site specific conditions using proper methods.

5.5. The potential for seismicity due to human activities<sup>5</sup> shall be considered.

5.6. The effect of ground motion shall be considered in combination with other seismically induced hazards.

## **VOLCANIC HAZARDS**

### **Requirement 17: Volcanic hazard evaluation**

**The hazards due to volcanic activity that have the potential to affect the safety of the nuclear installation shall be evaluated.**

5.7. Capable volcanos<sup>6</sup> shall be identified and evaluated. The evaluation shall consider the volcanic characteristics of the region surrounding the site, for sufficient distances to assure that the sources of potentially hazardous phenomena have been considered appropriately.

5.8. The hazards of capable volcanoes shall be evaluated to provide the input needed for the design or upgrading of the nuclear installation, as well as the deterministic and/or probabilistic safety analyses performed during the lifetime of the installation.

5.9. For new sites, it shall be screened out from the list of candidate sites, when reliable evidence shows the existence of a capable volcano that has the potential to affect the safety of the nuclear installation that cannot be compensated for through design and site protection measures.

5.10. The volcano hazards assessment shall be conducted using appropriately supporting numerical models, and shall consider adequately the uncertainties.

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<sup>5</sup> Such as dams, mining, oil and gas operation, etc.

<sup>6</sup> A capable volcano or volcanic field is one that: (i) has a credible likelihood of experiencing future activity during the lifetime of the installation and (ii) has the potential to produce phenomena that may affect the site of the installation.

5.11. The effect of volcanic phenomena shall be considered in combination with other volcanically induced hazards. This should include a consideration of volcanic ash fall.

## METEOROLOGICAL HAZARDS

### **Requirement 18: Extreme meteorological hazards evaluation**

**The extreme meteorological hazards and their possible combinations that have the potential to affect the safety of the nuclear installation shall be evaluated.**

5.12. Meteorological hazards such as wind, precipitation, snow and ice, air and water temperature, humidity, storm surges and sand / dust storms as well as the plausible combinations, shall be evaluated for their extreme values based on available documentation for an appropriate period of time. If necessary, efforts shall be made to extend the database (e.g. incorporating paleo-meteorological data, numerical models or simulations).

5.13. Appropriate methods shall be applied considering the available amount of data (measured and historical data), and known past changes in relevant characteristics of the region.

### **Requirement 19: Rare meteorological hazards evaluation**

**The potential for the occurrence of rare<sup>7</sup> meteorological hazards such as lightning, tornados and cyclones, including information on their severity and frequency shall be evaluated for the site.**

#### *Lightning*

5.14. If the impact to the safety of the nuclear installation cannot be screened out the potential for the occurrence and the frequency and severity of lightning shall be evaluated for the region of interest, together with the hazard posed by this phenomenon.

#### *Tornadoes and Cyclones*

5.15. The potential for the occurrence, frequency and severity of tornadoes, cyclones and associated missiles shall be evaluated in the region of interest, together with the hazard posed by these phenomena. The hazards associated with tornadoes and/or cyclones 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.

## FLOODING EVENTS

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<sup>7</sup> The terms 'rare' and 'extreme' are defined in IAEA document SSG-18.

## **Requirement 20: Flooding hazards evaluation**

**The hazard due to flooding for the nuclear installation shall be evaluated considering natural causes and/or human induced events including their possible combinations.**

### *Floods due to precipitation and other causes*

5.16. The potential for flooding in the region due to one or more natural causes such as storm surge, wind generating waves, extreme precipitation (including in combination due to a common cause or due to relatively high frequency of occurrence), which can affect the safety of the nuclear installation shall be evaluated.

5.17. Appropriate meteorological, hydrological and hydraulic models shall be developed to derive the flooding hazard for the site, including secondary effects such as debris, ice and sediments.

5.18. 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*

5.19. The potential for tsunamis or seiches in the region that can affect the safety of a nuclear installation on the site shall be evaluated. The potential for tsunamis or seiches from phenomena other than seismic sources shall be evaluated as appropriate for the region.

5.20. The hazards associated with tsunamis or seiches shall be derived from known historical records as well as from physical and/or analytical modelling. These include potential draw-down and run-up<sup>8</sup> that can result in physical effects on the site.

5.21. The hazards associated with tsunamis or seiches, with account taken of any amplification due to the coastal configuration at the site, such as nearshore bathymetry and coastal topography.

### *Floods and waves caused by failure of water control structures*

5.22. The upstream water control structures shall be analysed to determine potential hazard to the nuclear installation resulting from the failure of one or more of the upstream structures such as dams, including in combination with flooding from other causes.

5.23. If a preliminary examination of the nuclear installation indicates that it is not able to withstand safely the effects of the failure of one or more of the upstream structures, then the

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<sup>8</sup> Draw-down is a lowering of the water level at a coastal site. Run-up is a sudden surge of water up a beach or a structure.



hazards associated with the nuclear installation shall be assessed including such effects; otherwise the site shall be deemed unsuitable.

5.24. Flooding and associated phenomena caused by storage of water as a result of a blockage of rivers up or downstream (e.g., caused by landslides or ice) or a change in land use shall be considered.

## GEOTECHNICAL HAZARDS

### **Requirement 21: Geotechnical hazard evaluation**

**Geotechnical hazards including slope instability, collapse, subsidence or uplift, and soil liquefaction, shall be evaluated.**

#### *Slope instability*

5.25. The site and its vicinity shall be evaluated to determine the potential for slope instability (such as landslides, rock fall and snow avalanches) caused by natural or human induced phenomena that can affect the safety of the nuclear installation. In the evaluation of slope stability, the configuration of the site during and after site preparation activities shall be address. Also it shall take into account meteorological conditions and events, such as flooding.

5.26. The potential for slope instability resulting from seismic loading that can affect the safety of the nuclear installation shall be evaluated by using parameters consistent with the seismic hazard at the site including ground water characteristics.

#### *Collapse, subsidence or uplift of the site surface*

5.27. The hazards associated with the collapse, subsidence or uplift of the surface that can affect the safety of the nuclear installation over its lifetime shall be evaluated using a detailed description of subsurface conditions obtained from reliable methods of investigation.

#### *Soil liquefaction*

5.28. The potential for liquefaction and non-linear effects of the subsurface materials at the proposed site shall be evaluated by using parameters consistent with the seismic hazard at the site.

5.29. The evaluation of soil liquefaction shall include the use of accepted methods of field and laboratory testing in combination to analytical methods to determine the hazards.

### **Requirement 22: Geotechnical characteristics of subsurface materials**

**The geotechnical characteristics of the subsurface materials shall be investigated and a soil/rock profile for the site shall be determined.**

5.30. The stability of the foundation material and potential excessive settlement under static and seismic loading shall be assessed.

5.31. The groundwater regime and the chemical properties of the soil and groundwater shall be studied by appropriate methods and accounted for.

#### OTHER NATURAL HAZARDS

##### **Requirement 23: Evaluation of other natural hazards**

**In addition to the natural hazard listed above, other natural phenomena that are specific to the region and have the potential to affect the safety of the nuclear installations shall be investigated.**

5.32. The design basis for other natural external hazards like wild-fires, drought, hail, sub-surface freezing of subcooled water (frazil), diversion of a river and biological hazards (e.g. jelly fish, small animal, barnacle, etc.) shall be identified and assessed so that design basis for these events can be derived.

#### HUMAN INDUCED EVENTS

##### **Requirement 24: Evaluation of hazards due to human induced events**

**The hazards due to human induced events within or outside the site boundary shall be evaluated.**

5.33. Human induced events to be addressed include, but shall not be limited to, the hazards due to:

- nearby land, sea or air transport (collision, explosion...);
- fire, explosions, missile generation, releases of hazardous gases from stationary sources such as nearby industries to the site and;
- electromagnetic interference.

5.34. Human activities which may influence the type or severity of natural hazards, such as resource extraction or other significant re-contouring of land or water shall be considered.

##### *Aircraft crashes*

5.35. The potential for aircraft crashes on the site shall be assessed with account taken, to the extent practicable, of the potential changes in future air traffic and aircraft characteristics that can affect the aircraft crash hazard.

### *Chemical hazards*

5.36. Current or foreseeable 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 addressed.

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

## **6. THE POTENTIAL EFFECTS OF THE NUCLEAR INSTALLATION IN THE REGION**

This section addresses the requirements for assessing the impact of the nuclear installation on the surrounding population and the environment.

### **Requirement 25: Dispersion of radioactive material**

**Dispersion of radioactive material in air and water released from the nuclear installation under normal operating and accident conditions shall be assessed.**

#### *Atmospheric dispersion of radioactive material*

6.1. The analysis of the atmospheric dispersion of radioactive material shall be based on a meteorological description of the region, including descriptions of the regional orography and parameters of meteorological phenomena such as wind speed and direction, air temperature and quality, precipitation, humidity, atmospheric stability parameters, and prolonged inversions.

6.2. 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 and used in the analyses, together with any other relevant data that can be available from other sources.

#### *Dispersion of radioactive material through surface and ground water*

6.3. A programme of measurement and investigations relevant for radiological impact on the environment shall be carried out and used in the analyses to permit the assessment of radionuclide movement in the affected hydrological units.

6.4. A description of the groundwater and surface hydrological characteristics of the region (including interaction with between surface water and groundwater) 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 so that relevant information is available for the radiological impact assessment.

6.5. A programme of measurement shall be carried out to gather data relevant for the assessment of radionuclide movement in the affected hydrological units. A programme of investigation and measurements of the surface hydrology and groundwater shall be carried out for at least one full year prior to submittal of the site evaluation report and used in analyses to determine to the extent necessary the dilution and dispersion characteristics of water bodies, the re-concentration ability of sediments and biota, migration and retention characteristics of radionuclides and the determination of transfer mechanisms of radionuclides in the hydrosphere and along exposure pathways.

6.6. A programme of hydrogeological investigations shall be carried out prior to submission of the site evaluation report and used in the analyses to assess radionuclide movement in hydrogeological units. This programme shall include investigations of the migration and retention characteristics of radionuclides in groundwater and their exposure pathways.

6.7. 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 water and data on the uses of groundwater in the region.

#### **Requirement 26: Population distribution and public exposure**

**The distribution of the population within the region over the lifetime of the installation shall be determined and evaluation of the potential impact of radioactive releases, either due to normal operation or under accident conditions, on the population shall be performed.**

6.8. Information on existing and projected population distributions in the region, including resident populations and to the extent possible transient population shall be collected and kept up to date over the lifetime of the installation. Special attention shall be paid to vulnerable populations and institutions such as schools, hospitals and prisons when considering the feasibility to implement protective measures.

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

6.10. The data shall be analysed to obtain the population distribution in terms of the direction and distance from the installation. This information shall be used to perform an evaluation of the potential radiological impact 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 and models as appropriate.

**Requirement 27: Uses of land and water in the region**

**The uses of land and water shall be characterized in order to assess the potential effects of the nuclear installation in the region.**

6.11. The investigation shall cover land and resources of surface and ground waters that may be used by the population or that serve as habitat for organisms in the food chain.

**7. MONITORING AND PERIODIC RE-EVALUATION OF THE SITE**

This section provides requirements for the monitoring of hazards and the periodic reassessment of site related hazards and conditions that can affect safety over the entire lifetime of the nuclear installation.

**Requirement 28: Monitoring of external hazards and site conditions**

**All external natural and human induced hazards and site conditions that are pertinent to the licensing and safe operation of the installation shall be monitored over the entire lifetime of the nuclear installation.**

7.1. This monitoring shall be commenced no later than the start of construction and shall be continued up until decommissioning. The monitoring plan shall be developed as part of the objectives and scope of the site evaluation.

7.2. The monitoring plan shall include the monitoring target and type of data, location, methodology, data collection frequency, resolution and precision, data recovery requirements, operational procedures and management, as well as requirements on data processing and analysis.

7.3. 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 operation of the nuclear installation.

**Requirement 29: Reassessment of external hazards and site conditions**

**All external natural and human induced hazards and site conditions that are covered in this Safety Requirements publication shall be reassessed by the operating organization**

**as part of safety reviews and as appropriate throughout the operating lifetime of the nuclear installation, with due account taken of operating experience and significant new safety related information from the relevant sources.**

7.4. As part of safety reviews such as periodic safety reviews or safety assessments under alternative arrangements, external natural and human induced hazards shall be reassessed based on updated information throughout the lifetime of the nuclear installation, at regular intervals and as frequently as necessary (typically no less than once in ten years) and in the event of any of the following:

- (a) An update of the regulatory requirements;
- (b) Inadequate design against external hazards;
- (c) New technical findings, such as the vulnerability of selected structures and/or non-structural elements to any external hazards;
- (d) New experience and lessons from the occurrence of actual external events affecting the safety of nuclear installations or hazardous facilities;
- (e) Changes of hazards over time, for which new information and assessments are available;
- (f) To provide confidence that there are sufficient margins to prevent cliff edge effects;
- (g) As part of a programme of long term operation, or a life extension.

7.5. The implications of such a reassessment of site specific hazards or of data relevant for the radiological impact assessment for the safe operation of the nuclear installation shall be evaluated.

## 8. REFERENCES

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## 9. CONTRIBUTORS TO DRAFTING AND REVIEW

Al-Hanai, W.	Federal Authority for Nuclear Regulation, United Arab Emirates
Altinyollar, A.	International Atomic Energy Agency
Blahoianu, A.	Private Consultant, Canada
Cabane, F.	Électricité de France, France
Campbell, A.	United States Nuclear Regulatory Commission, United States
Coman, O.	International Atomic Energy Agency
Contri, P.	ENEL Ingegneria & Ricerca S. p. A., Italy
De Vos, M.	Canadian Nuclear Safety Commission, Canada
Delattre, D.	International Atomic Energy Agency
Delves, D.	International Atomic Energy Agency
Dubinsky, M.	Rizzo Associates, Inc., United States
Godoy, A.	Private Consultant, Argentina
Gürpınar, A.	Private Consultant, Turkey
Haddad, J.	International Atomic Energy Agency
Iijima, T.	Nuclear Regulation Authority, Japan
Jiménez Juan, A.	Consejo de Seguridad Nuclear, Spain
Kara, A.	Turkish Atomic Energy Authority, Turkey
Kock, A.	United States Nuclear Regulatory Commission, United States
Lee, H.	Korea Institute of Nuclear Safety, Republic of Korea
Mitchell, T.	Tractebel Engineering, GDF Suez, Belgium
Morita, S.	International Atomic Energy Agency
Pino, G.	ITER Consult, Italy
Susilo, M.	National Nuclear Energy Agency, Indonesia
Uchida, J.	Nuclear Regulation Authority, Japan
Fukushima, Y.	International Atomic Energy Agency