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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 the edition of Site Evaluation for Nuclear Installations that was issued in 2016 as IAEA Safety Standards Series No. NS-R-3 (Rev. 1)¹. NS-R-3 (Rev. 1) was a partial revision of IAEA Safety Standards Series No. NS-R-3² issued in 2003 and it took into account issues highlighted after the Fukushima Daiichi accident. This Safety Requirements publication takes into account and incorporates developments relating to site evaluation for nuclear installations since 2003. It applies 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 evolve with these advances and this publication reflects the present consensus among States.

1.2. This Safety Requirements publication establishes requirements and provides criteria for site evaluation in order to meet the fundamental safety objective [1]. Several related Safety Guides provide on how to meet the requirements established in this publication [2–8].

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 such that the site related hazardous phenomena and characteristics are adequately taken into account, so that the corresponding site specific design parameters³ are appropriate;
- c) Analysing the characteristics of the population and the region surrounding the site so as to determine whether there would be significant difficulties in planning to implement emergency response actions effectively.

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

² INTERNATIONAL ATOMIC ENERGY AGENCY, Site Evaluation for Nuclear Installations, IAEA Safety Standards Series No. NS-R-3, IAEA Vienna, (2003).

³ Site specific design parameters are used to show that are enveloped by the those used in the development of the design and the installation is adequate for the selected site otherwise the design should be modified accordingly.

The criteria described above are to be applied:

- i. To identify the external natural and human induced events that could challenge the safety of the nuclear installation;
- ii. To assess the interactions between the site and nuclear installation for operational states and accident conditions, over the lifetime of the nuclear installation, including those accidents that could necessitate proper implementation of emergency response actionsplans.

1.4. This publication is intended for use by regulatory bodies in establishing regulatory requirements, and by operating organizations or their contractors in conducting site evaluation for nuclear installations.

SCOPE

1.5. These requirements in this publication apply to the following nuclear installations [9]:

- Nuclear power plants;
- Research reactors (including subcritical and critical assemblies) and any adjoining radioisotope production facilities;
- Storage facilities for spent fuel;
- Facilities for the enrichment of uranium;
- Nuclear fuel fabrication facilities;
- Conversion facilities;
- Facilities for the reprocessing of spent fuel;
- Facilities for the predisposal management of radioactive waste arising from nuclear fuel cycle facilities;
- Nuclear fuel cycle related research and development facilities.

1.6. This Safety Requirements publication covers site evaluation for both new and existing nuclear installations. For existing facilities, decisions concerning implementation of new or enhanced safety features may consider, as practicable, safety significance, economic, social and environmental factors.

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 an emergency response [10]. The site area is typically the area within the security perimeter fence or other designated property marker.

1.8. The ‘external zone’ is 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 response actions [9].

1.9. The ‘region’ in the context of this publication is the region surrounding the site and is generally intended to include more than the external zone. The region is to be determined for investigation of specific hazards. It is also known as the ‘geographical area of interest’.

1.10. The external human induced events considered in this Safety Requirements publication are of accidental origin. Considerations relating to physical protection of the nuclear installation against sabotage, and to physical protection against unauthorized removal or sabotage of the nuclear material, are outside the scope of this publication although such considerations may bear significant safety implications for site evaluation. This publication does not address the threat assessment of human activities of malevolent origin. Recommendations for the establishment of the design basis threat for structures, systems and components important to nuclear security are provided in IAEA Nuclear Security Series No. 13 [11] and in supporting publications in the IAEA Nuclear Security Series.

1.11. However, the interface between safety and nuclear security has to be considered. Site specific design parameters used for the qualification of structures, systems and components important to safety against external natural and human induced hazards, as required in this publication, can also be used for the qualification of structures, systems and components important to nuclear security against relevant external hazards.

1.12. The siting process for a nuclear installation is divided into two stages⁴:

- a) Site survey, in which candidate sites are identified after the investigation of a large region and the rejection of unsuitable sites;
- b) Site Selection, in which the candidate sites are assessed by screening, evaluation, comparison and ranking on the basis of safety and other considerations to select one or more ‘preferred candidate sites’.

The suitability of the site is then confirmed in the site evaluation process. The site evaluation process starts with the second stage of the siting process (namely site selection), and continues throughout the entire lifetime of the nuclear installation. Detailed site evaluation (for the selected site) provides input to the preliminary safety analysis report and the final safety analysis report. Site evaluation continues throughout the operation stage of the nuclear

⁴ More details about the siting and site evaluation process are presented in the SSG-35 [8].

installation with confirmatory and monitoring activities of the site specific design parameters as well as safety re-evaluations based on the outcome of periodic safety reviews.

1.13. 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 people or the environment over the lifetime of the nuclear installation. Non-radiological aspects of the environmental impact of the site and the nuclear installation are not covered in this publication.

STRUCTURE

1.14. Section 2 of this publication sets out the safety principles and objectives applicable to site evaluation. Section 3 establishes requirements for the application of the management system for site evaluation. Section 4 establishes the general requirements that are applicable to all types of external hazard and all types of nuclear installation. Section 5 establishes requirements for specific technical aspects related to evaluation of natural and human induced external hazards. Section 6 establishes requirements for specific technical aspects related to site evaluation of the effects of the nuclear installation on the environment around the nuclear installation (including the atmosphere, the hydrosphere and the biosphere), and on the population. Section 7 establishes requirements for monitoring and periodic review of external natural and human induced hazards and site conditions throughout the lifetime of the nuclear installation.

2. SAFETY PRINCIPLES AND CONCEPTS

2.1. As stated in SF-1 [1], “**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 facilities are operated and activities are conducted so as to achieve 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.”

2.2. 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.”

2.3. This Safety Requirements publication establishes requirements that apply for implementation of Principles 8 and 9 of SF-1 [1]:

- a) Principle 8 on prevention of accidents states: “**All practical efforts must be made to prevent and mitigate nuclear or radiation accidents.**” Paragraph 3.31 of SF-1 [1] states: “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”. Paragraph 3.32 of SF-1 [1] states that one of the elements is related to “Adequate site selection and the incorporation of good design and engineering features providing safety margins, diversity and redundancy”.

To address Principle 8:

Site evaluation for a nuclear installation shall characterize the natural and human induced hazards that may challenge the safety of the nuclear installation. The site evaluation shall provide adequate input to the design and safety assessment relating to site specific parameters (see Requirement 2).

- b) Principle 9 on emergency preparedness and response states: **“Arrangements must be made for emergency preparedness and response for nuclear or radiation incidents.”**

To address Principle 9:

Site evaluation for a nuclear installation shall provide adequate input for demonstration of protection of people and the environment from the radiological consequences of radioactive releases due to accidents. The site evaluation shall identify the site characteristics that could impact the feasibility of planning to implement emergency response actions in the external zone (see Requirement 2).

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 in accordance with a management system.

3.1. An integrated management system 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 [12]. The management system shall be implemented at the earliest possible time in the conduct of site evaluation for the nuclear installations.

3.2. The management system shall ensure the quality and the control of the activities performed at each stage of site evaluation.

3.3. Site evaluation shall include, as part of the management system, proper quality assurance arrangements covering each activity that can influence safety or affect the derivation of site specific design parameters and other safety related site characteristics. The quality assurance arrangements shall be consistent with regulatory requirements and their application shall be graded in accordance with the importance to safety of the activity under consideration.

3.4. For each site evaluation activity, including inspection, testing, verification and/or validation, the acceptance criteria and the responsibilities for performing the activity shall be specified.

3.5. The results of studies and investigations from the site evaluation shall be documented in sufficient detail to permit an independent review.

3.6. An independent review shall be made of the evaluation of the site related external natural and human induced hazards and site specific design parameters- and the potential radiological impact of the nuclear installation on people and environment.

4. GENERAL REQUIREMENTS FOR SITE EVALUATION

Requirement 2: Safety objectives in site evaluation for nuclear installations

The safety objectives in site evaluation for nuclear installations shall be (a) to characterize the natural and human induced hazards that might challenge the safety of the nuclear installation and (b) to provide adequate input for demonstration of the sufficient protection of people and the environment from harmful effects of ionizing radiation. ~~radiological consequences of radioactive releases due to accidents.~~

4.1. The safety objectives in site evaluation are derived based on the fundamental safety objective [1] ~~relate to both short term and long term radiological impact on people and the environment.~~

4.2. Demonstration of compliance with the safety requirements established in this publication provides the basis for demonstration of achieving the safety objectives in site evaluation.

Requirement 3: Scope of the site evaluation for nuclear installations

The scope of the site evaluation shall encompass both factors relating to the site and factors relating to the interaction between the site and the installation, for all operational states and accident conditions, including accidents that could warrant emergency response actions.

4.3. The scope of the site evaluation shall cover all external hazards and site specific parameters relevant for the safety of the nuclear installation. In determining the scope of the site evaluation, a graded approach shall be applied on the basis of the radiation risk posed to people and the environment.

4.4. ~~For nuclear installations other than nuclear power plants, t~~The application of the safety requirements for analysis, evaluation and documentation shall be commensurate with the potential hazards associated with the nuclear installation.

4.5. The level of detail needed in an evaluation to meet the requirements established in this publication shall be commensurate with the risk associated with the nuclear installation and its site and will differ depending on the type of nuclear installation.

4.6. The scope and depth of the site evaluation process necessary to support the safety demonstration for the nuclear installation shall be determined.

4.7. For nuclear installations other than nuclear power plants, the following shall be taken into consideration in application of a graded approach:

- a) The amount, type and status of the radioactive inventory at the site (e.g. whether the radioactive material on the site is in solid, ~~or~~ fluid or gaseous form, and whether the radioactive material is being processed in the nuclear installation or is being stored on the site);
- b) The intrinsic hazards associated with the physical and chemical processes that take place at the nuclear installation;
- c) For research reactors, the thermal power;
- d) The distribution and/or location of radioactive sources in the nuclear installation;
- e) The configuration and layout of installations designed for experiments, and how these are likely to change;
- 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 in the event of an accident.

Requirement 4: Site suitability

The suitability of the site shall be assessed at an early stage of the site evaluation and shall be confirmed for the lifetime of the planned nuclear installation.

4.8. In the assessment of the suitability of a site for a nuclear installation, the following aspects shall be addressed at an early stage of the site evaluation:

- a) The effects of external events occurring in affecting the region surrounding the and affecting particular site (external events can be of natural origin or human induced);
- b) The characteristics of the site and its environment that could influence the transfer to people and to the environment of radioactive material being released from the nuclear installation;
- c) The population density, population distribution and other characteristics of the external zone in so far as they could affect the feasibility of planning to implement emergency response actions effectively, as required in GSR Part 7 [10], 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 installation if the site evaluation for one or more of the three aspects cited in para 4.8 indicates that site is unacceptable and the deficiencies cannot be compensated for by means of a proper balance of measures for site protection, design features of the nuclear installation and administrative procedures.

4.10. Site suitability shall be assessed on the basis of current and relevant data and methodologies and shall be consistent with planned operations at the site. If relevant

Conservative criteria shall be developed in relation to site specific accident scenarios and the consistency of such criteria with the overall site suitability shall be demonstrated.

4.11. A decision regarding the site's suitability shall be based on the characteristics of the nuclear installation, the amount and nature of potential radiological releases and their impact on people and 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 later determined or anticipated that the installed nuclear capacity – for nuclear power plants - and the inventory of nuclear material – for all other nuclear installations 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. In the overall evaluation of site suitability, site specific attributes such as cooling water availability or extreme environmental conditions shall also be addressed regarding their potential role in affecting the safe, continuous operation of the nuclear installation.

Requirement 5: Site and regional characteristics

The site and the region shall be investigated with regard to the characteristics that can impact ~~nuclear~~ safety of nuclear installation and the potential radiological impact of the nuclear installation on people and the environment.

4.14. Natural phenomena as well as human activities in the region with potential to induce hazards at the site that may affect the safety of the nuclear installation shall be identified and evaluated. The extent of this evaluation shall be graded in accordance with the safety significance of the potential hazards at the site.

4.15. Characteristics of the natural environment in the region that can be affected by the potential radiological impact of the nuclear installation shall be investigated and assessed, for all operational states and accident conditions and for all stages of the lifetime of the nuclear installation (See Section 6).

4.16. The size of the region to be investigated shall be defined for each of the external natural hazards and associated activities. Both the magnitude of the hazard and the distance from the source of the hazard to the site shall be considered in determining the size of the region to be investigated. For certain external natural phenomena, such as tsunamis and volcanic phenomena, it shall be ensured that the size of the region surrounding the site is sufficiently large to address the potential effects of these hazards at the site.

4.17. The site and the region shall be studied to evaluate the present and foreseeable future characteristics that could have an impact on ~~nuclear installation~~ safety of nuclear installation. This includes potential changes in the magnitude and/or frequency of the natural hazards, the distribution of the population in the region, the present and future use of land and water, the further development of existing nuclear installations or the construction of facilities that can impact on the safety of the nuclear installation or the feasibility of planning the implementation of 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 that could affect the region shall be identified through a screening process.

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

4.19. The scope of evaluation of external events shall cover the full range of severity and frequency of occurrence relevant for the design and safety assessment, including events of high severity but low probability that could contribute to the overall risk.

4.20. External hazards that are not excluded on the basis of the screening process shall be evaluated and selected for the purpose of establishing the site specific design parameters or for re-evaluating the site, in accordance with the significance of these hazards to the safety of the nuclear installation.

~~4.21. For hazards and their associated events that are excluded on the basis of the screening process, it shall be ensured that all effects relevant for design and/or safety assessment resulting from these events are bounded by the effects associated with other events or a set of events. An event may be screened out through enveloping within a set of events. However, it shall be ensured that all effects of the screened-out event are bounded by this 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 over the lifetime of the nuclear installation.

4.22. ~~Proposed~~ The 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 nuclear installation.

4.23. Information on frequency and severity of external events derived from the characterization of the hazards shall be used in establishing the site specific design parameters for the nuclear installation. Adequate account shall be taken of both aleatory and epistemic uncertainties in the site specific design parameters.

4.24. Appropriate methods, supported by numerical models when necessary, shall be used to derive hazard 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 hazard evaluation.

4.25. The decision to use deterministic and/or probabilistic methodologies in hazard evaluation shall be based on the nature of the hazard, the availability of data and the applicable requirements for safety assessment.

4.26. Special consideration shall be given to the use of applicable probabilistic methodologies and the use of probabilistic hazard curves representing external events as input for probabilistic safety assessment for external hazards. Such probabilistic hazard curves shall be developed with reference to the specific site conditions.

4.27. Hazard evaluations shall address the possibility that external events can occur in combination, simultaneously or within short time frames. Interrelationships and causality between external events shall be evaluated.

4.28. The results of hazard evaluations shall be expressed in terms that can be used as input for deriving the site specific design parameters for the nuclear installation; that is, appropriate parameters for describing the severity of the hazard effects shall be selected or developed.

4.29. The possible ~~non-radiological impact of the nuclear installation, due to~~ chemical or thermal releases, ~~and~~ the potential for explosion and the ~~dispersion of~~ chemical products that may affect safety functions of the nuclear installations or dispersion characteristics of radio nuclides shall be ~~taken into account~~ considered in the site evaluation process.

4.30. The potential for interactions between radioactive and non-radioactive effluents, such as interactions due to the combination of heat or chemicals with radioactive material in liquid effluents, shall be considered.

Requirement 8: Measures for site protection

If the projected design of the nuclear installation is not able to withstand safely the impact of external natural and human induced hazards, the need for site protection measures shall be evaluated.

4.31. The need for protection of the site against the effects of specific phenomena of external natural and human induced hazards shall be evaluated considering adequate safety margins.

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

4.33. If measures for site protection are required to be implemented, uncertainties shall be properly taken into account in the evaluation of the extreme values of external natural and human induced hazards associated with the measures for site protection. Measures for site protection shall be classified, designed, built, maintained and operated as structures, systems and components important to safety.

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

The site evaluation shall consider the potential for external natural and human induced hazards to affect multiple nuclear installations on the same site as well as at co-located sites.

4.34. Occurrences of external natural and human induced events and their credible combinations that are able to challenge the safety of multiple installations on the same site or installations on co-located sites shall be considered. The potential for hazards originating from one nuclear installation to affect other nuclear installations located on the same site or at co-located sites shall be assessed.

4.35. The combined effects of nuclear installations located on the same site or at nearby sites on the public and the environment shall be evaluated for region affected by the identified accident scenarios (see Requirement 12).

Requirement 10: Changes 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 potential impact of these changes shall be evaluated.

4.36. The natural and human induced hazards affecting the safety of a nuclear installation as well as the site characteristics that can change over time shall be identified. The potential consequences of such changes shall be duly assessed for the planned operating lifetime of the nuclear installation.

4.37. Due account shall be taken of uncertainties in the projections of any potential changes in time of the external hazards and site characteristics by means of appropriate safety margins in the related site specific design parameters.

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.

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

~~a) Ice, including frazil ice;~~

~~b) Oil and chemical spills;~~

e)a) Air temperature and humidity;

d)b) Water depth and temperature;

e)c) Water quality characteristics, including turbidity, suspended solids, floating debris, and chemical and biochemical changes (both natural and human induced changes);

f)d) Availability and sustainability of the 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.

4.39. All external natural and human induced events that can cause a loss of the ultimate heat sink shall be identified and evaluated.

Requirement 12: Potential effects of the nuclear installation on people and the environment of the region.

In determining 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 nuclear installation and its safety features.

4.40. The potential effects of the nuclear installation on people and the environment shall be evaluated considering its postulated accident scenarios (including resulting source terms) and the feasibility of planning to implement emergency response actions effectively at the site and in the external zone. These estimates shall be confirmed when the design of the nuclear installation and its safety features have been established.

4.41. 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 this 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 implementing planned emergency response actions effectively

The feasibility implementing planned emergency response actions effectively on the site and in the external zone shall be evaluated, with account taken of site characteristics and characteristics of the external zone and any external events that could hinder the establishment of complete emergency arrangements prior to operation.

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

4.43. An assessment shall be made of the feasibility of planning to implement response actions effectively as required in GSR Part 7 [10]. Nuclear installations on the same site and co-located at nearby sites shall be considered in the assessment, with special emphasis on nuclear installations that can experience concurrent accidents.

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

4.45. It shall be demonstrated that the information provided to assess ~~radiation risk~~potential effects to the population associated with accident conditions, including those that could warrant emergency response actions being taken in the external zone, is compliant with the safety objectives in site evaluations~~site safety objectives~~.

Requirement 14: Data collection in site evaluation for nuclear installations

The data necessary to perform an assessment of external natural and human induced hazards and to assess both the impact of the environment on the nuclear installation

safety and the impact of the nuclear installation on public and the environment shall be collected.

4.46. Data regarding external natural and human induced hazards with the potential to give rise to adverse effects on the safety of the nuclear installation shall be collected throughout the lifetime of the nuclear installation. Data shall be confirmed to be spatially and temporally pertinent to the site, with preference given to the use of site specific data in site evaluation.

4.47. The extent, objectives and scope of the data collection process shall be defined on the basis of safety objectives for site evaluation, graded in accordance with the hazard posed by the nuclear installation to people and the environment.

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

- a) Information on external natural and human induced hazards: sources of hazards, propagation of hazards, potential effects on the nuclear installation ~~and on workers,~~ public and the environment;
- b) Information describing site conditions and regional environmental conditions;
- c) Information on the proposed engineering and administrative protective site features and mitigation measures;
- d) Information on the potential impact of the nuclear installation on public and the environment as a result of both normal operation as well as accidents;
- e) Information required for planning emergency actions on the site and off the site in all environmental conditions and conditions of the nuclear installation;
- f) Information on conditions for access to the site and site infrastructure.

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 shall be analysed for reliability, accuracy, temporal pertinence and completeness.

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

4.51. The data collected for the site investigations shall be of sufficiently quality and quantity detailed to support the selected methodology for hazard evaluation.

4.52. The details of the information collected for each hazard shall be appropriate to the distance from the source of the hazard to the site and the potential impact on the site. The sources of uncertainties relating to data collection shall be documented.

5. EVALUATION OF EXTERNAL HAZARDS

5.1. This section establishes requirements for the evaluation of external hazards. These requirements are to be applied as appropriate for the type of nuclear installation as well as the site under consideration.

SEISMIC HAZARDS

Requirement 15: Evaluation of fault capability

Faults beyond a certain size and within a certain distance of the nuclear installation that are significant to safety shall be evaluated to identify whether these faults are to be considered capable faults. For capable faults, potential challenges to the safety of the nuclear installation in terms of ground motion and/or fault displacement hazard shall be evaluated.

5.2. Capable faults⁵ shall be identified and evaluated. The evaluation shall consider the fault characteristics in the vicinity of the site. The methods used and the investigations made shall be sufficiently detailed to support safety related decisions.

5.3. The effect of fault displacement on safety related structures, systems and components shall be evaluated. Evaluation of fault displacement hazard shall include detailed geological mapping of excavations for safety related engineered structures to enable evaluation of fault capability at the site.

5.4. ~~If a capable fault is identified in the vicinity of the site of a new or existing nuclear installation and the safety of the nuclear installation cannot be demonstrated, the site shall be deemed unsuitable. For the new sites, an alternative site shall be considered when reliable evidence shows the existence of a capable fault and its effects cannot be compensated by design/engineering protective measures. In case of a capable fault is identified in the site vicinity of an existing nuclear installation, the site shall be deemed unsuitable if the site safety cannot be demonstrated.~~

⁵ 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) The fault 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: Evaluation of ground motion hazards

An evaluation of ground motion hazards shall be conducted to provide the input needed for the seismic design or 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 nuclear installation.

5.5. Hazards due to earthquake induced ground motion shall be assessed by means of appropriate methods.

5.6. The potential for seismicity due to human activities⁶ shall be considered.

5.7. The effect of the vibratory ground motion in combination with other seismically induced hazards, if any, shall be considered.

VOLCANIC HAZARDS

Requirement 17: Evaluation of volcanic hazards

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

5.8. Capable volcanos⁷ shall be identified and evaluated. The evaluation shall consider the volcanic characteristics of the region for sufficient distances to ensure that potentially hazardous volcanic phenomena are considered appropriately.

5.9. The hazards of capable volcanos shall be evaluated to provide the input needed for determining the site specific design parameters or for re-evaluating the site, as well as for deterministic and/or probabilistic safety analyses performed during the lifetime of the nuclear installation.

5.10. A proposed new site shall be screened out from the list of candidate sites if reliable evidence shows the existence of a capable volcano that has the potential to affect the safety of the nuclear installation and which cannot be compensated for through design features and/or measures for site protection.

5.11. Volcanic hazard assessment that focuses on determining the geological characteristics of volcanic phenomena and their spatial extent will usually be more certain than one focusing on an estimation of the likelihood of occurrence of hazardous phenomena. Therefore, volcanic

⁶ Such as construction of dams, mining, and operation of oil wells and gas wells.

⁷ A capable volcano is a volcano that has a credible likelihood of undergoing future activity and producing hazardous phenomena, including non-eruptive phenomena, during the lifetime of a nuclear installation concerned which may potentially affect the site.

hazards shall be assessed using appropriate information, methods and/or models, with adequate account taken of the uncertainties. ~~in the information and models.~~

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

METEOROLOGICAL AND HYDROLOGICAL HAZARDS

Requirement 18: Evaluation of extreme meteorological hazards

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

5.13. Meteorological phenomena such as wind, precipitation, snow and ice, air and water temperature, humidity, storm surges and sand or dust storms, as well as their credible combinations, shall be evaluated for their extreme values⁸ based on available records. If necessary, efforts shall be made to extend the database on meteorological hazards (e.g. by incorporating historical climate data, numerical models and simulations).

5.14. Appropriate methods shall be applied for ~~deterministic and/or probabilistic~~ evaluation of the hazards considering the amount of data available (both measured data and historical data) and known past changes in relevant characteristics of the region.

Requirement 19: Evaluation of rare meteorological hazards

The potential for the occurrence of rare⁹ meteorological events such as lightning, tornados and cyclones, including information on their severity and frequency, shall be evaluated for the site.

Lightning

5.15. ~~If the impact on 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 site vicinity.

Tornados and cyclones

5.16. The potential for the occurrence and the frequency and severity of tornados, cyclones and associated missiles shall be evaluated in the region. The hazards associated with tornados and cyclones shall be derived and expressed in terms of parameters such as rotational wind speed,

⁸ Extreme values of meteorological parameters are identified by means of statistical analysis of recorded parameters that are measured periodically on an ongoing basis.

⁹ Rare meteorological events are unlikely to be measured at any specific location because of their very low frequency of occurrence at any single place and the destructive effects of the phenomena, which may result in damage to standard measuring instruments.

translational wind speed, radius of maximum rotational wind speed, pressure differentials and rate of change of pressure.

FLOODING HAZARDS

Requirement 20: Evaluation of flooding hazards

Hazards due to flooding shall be evaluated for the site, considering natural causes and human induced events including their possible combinations.

Floods due to precipitation and other causes

5.17. The potential for flooding in the region surrounding the site due to one or more natural causes, such as storm surge, wind generated waves, or meteotsunamis and seiches generated by traveling atmospheric disturbances, extreme precipitation including such events in combination due to a common cause or due to a relatively high frequency of occurrence shall be evaluated.

5.18. Appropriate meteorological, hydrological and hydraulic models shall be developed to derive the flooding hazards for the site, including secondary effects such as debris, ice and sediments. Where feasible, information from studies of historic and prehistoric floods shall be used to inform estimates of the frequency and magnitude of riverine floods.

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

Water waves induced by earthquakes or other geological phenomena

5.20. 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 (such as submarine land slide, etc.) shall be evaluated as appropriate for the region.

5.21. The hazards associated with tsunamis or seiches shall be derived from historical records, available prehistoric floods information as well as from physical and/or analytical modelling. Such hazards shall include potential draw-down and run-up¹⁰ that can result in physical effects on the site.

¹⁰ 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.

5.22. The hazards associated with tsunamis or seiches shall be evaluated as appropriate for the region, with account taken of any amplification due to the coastal configuration including artificial structures at the site, using nearshore bathymetry and coastal topography.

Floods and waves caused by failure of water control structures

5.23. Upstream water control structures such as dams shall be analysed to determine the potential hazard associated with the failure of one or more of the upstream structures, including in combination with flooding from other causes.

5.24. If a preliminary examination of the nuclear installation indicates that it would not be able to withstand safely the effects of the failure of one or more of the upstream structures, then the hazards associated with the nuclear installation shall be assessed with the inclusion of such effects; otherwise such upstream structures shall be analysed by methods equivalent to those used in determining the hazards associated with the nuclear installation to show that the upstream structures could survive the event concerned. ~~in the absence of such an assessment, the site shall be deemed unsuitable.~~

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

GEOTECHNICAL AND GEOLOGICAL HAZARDS

Requirement 21: Geotechnical characteristics and geological features of subsurface materials

The geotechnical characteristics and geological features of subsurface materials shall be investigated, and a soil and rock profile for the site that considers the variability and uncertainty in subsurface materials shall be derived.

5.26. Static and dynamic geotechnical characteristics and geological features of subsurface materials at the site, including any backfill, shall be established. Laboratory and field-based methods shall be used, in conjunction with appropriate sampling techniques and sufficient repetition of each test, to characterize each parameter of the subsurface materials at the site.

5.27. The stability and bearing capacity of foundation materials shall be assessed, including consideration of the potential for excessive settlement under static and seismic loading.

5.28. The physical and the geo-chemical properties of the soil and groundwater shall be studied by appropriate methods and taken into account.

Requirement 22: Evaluation of geotechnical and geological hazards

Geotechnical and geological hazards, including slope instability, collapse, subsidence or uplift, soil liquefaction, ~~zones of high geological stress~~ and their effect on safety of the nuclear installation, shall be evaluated.

Slope instability

5.29. 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 instability, the configuration of the site during and after site preparation activities shall be addressed. The evaluation of slope stability shall also take into account extreme meteorological conditions and rare events.

5.30. The potential for slope instability resulting from seismic loading shall be evaluated using parameters appropriate for describing the seismic hazards and the soil and groundwater characteristics at the site.

Collapse, subsidence or uplift of the site surface

5.31. The potential for 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. ~~Non-tectonic surface deformation at the site shall be included in the geotechnical hazard evaluation.~~

Soil liquefaction

5.32. The potential for liquefaction and non-linear effects of the subsurface materials at the proposed site shall be evaluated using parameters appropriate for describing the seismic hazards and geotechnical properties of the subsurface materials at the site.

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

OTHER NATURAL HAZARDS

Requirement 23: Evaluation of other natural hazards

Other natural phenomena that are specific to the region and which have the potential to affect the safety of the nuclear installation shall be investigated.

5.34. Other natural external hazards, such as wild-fires, drought, hail, frazil ice formation, diversion of a river, debris avalanche and biological hazards (e.g. jellyfish, small animals, and

barnacles) shall be identified and assessed so that the site specific design parameters for these hazards 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 area shall be evaluated.

5.35. Human induced events to be addressed shall include, but shall not be limited to:

- a) Events associated with nearby land, river, sea or air transport (e.g. collisions and explosions);
- b) Fire, explosions, missile generation and releases of hazardous gases from industrial facilities near the site;
- c) Electromagnetic interference.

5.36. Human activities that might influence the type or severity of natural hazards, such as resource extraction or other significant re-contouring of land or water or reservoir-induced seismicity, shall be considered.

Aircraft crashes

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

Chemical hazards

5.38. Current or foreseeable activities in the region surrounding the site 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.

5.39. 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, and the worst combinations of atmospheric conditions at the site. In addition, the potential effects of such events on site workers shall be evaluated.

6. EVALUATION OF POTENTIAL EFFECTS OF THE NUCLEAR INSTALLATION ON THE REGION

Requirement 25: Dispersion of radioactive material

The dispersion in air and water of radioactive material released from the nuclear installation in operational states and accidents~~s-conditions~~ shall be assessed.

Atmospheric dispersion of radioactive material

6.1. The analysis of the atmospheric dispersion of radioactive material shall account for a description of regional orography, land cover and meteorological features of the region, including parameters such as wind speed and direction, air temperature, precipitation, humidity, atmospheric stability parameters, prolonged atmospheric inversions and any other parameters required for ~~dispersion~~~~inversion~~ modelling purpose. If possible, long-term meteorological data for nearby locations shall be obtained, evaluated for quality and used.

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 locations and sampling intervals. Data from at least one representative full year shall be collected and used in the analyses, together with any other relevant data that are available from other sources. The meteorological data shall be expressed in appropriate meteorological parameters.

Dispersion of radioactive material through surface water and groundwater

6.3. A survey programme shall be designed to gather relevant data to characterize the hydrogeological and hydrological parameters at the site location and in the region to permit the assessment of dynamics of radionuclides in the potentially affected hydrological units and the subsequent assessment of the radiological impact. This programme of measurement shall be carried out for at least one full year prior to hydrogeological investigations (see para. 6.7). The data shall be expressed in appropriate parameters for surface hydrology and groundwater.

6.4. A program of surface water investigations in the region (including the interactions between surface water and groundwater) shall be developed. The descriptions of the surface waters shall include the main physical and chemical characteristics of the 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.

6.5. A program of the hydrogeological investigations of the region shall be developed, including descriptions of the main characteristics of the water bearing formations and their interaction with surface water and data on the uses of groundwater in the region.

6.6. The programme of hydrogeological investigations shall include investigations of the migration and retention characteristics of radionuclides in groundwater and associated exposure pathways.

6.7. The hydrogeological and hydrological investigations shall 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.

Requirement 26: Population distribution and ~~exposure of the public~~ exposure

The distribution of the population within the region over the lifetime of the nuclear installation shall be projected and evaluation of the potential impact of radioactive releases, in both operational states and accident ~~conditions~~, on the population shall be conducted and periodically updated.

6.8. 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 nuclear installation. Special attention shall be paid to vulnerable populations and residential institutions such as schools, hospitals, nursing homes and prisons when evaluating the potential impact of radioactive releases and considering the feasibility of implementing protective actions.

6.9. The most recent census data for the region, or information obtained by extrapolation of the most recent data on resident and temporary populations, 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 nuclear installation. This information shall be used to carry out 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 on the region.

6.11. The investigation shall cover land and resources of surface water and groundwater that might be used by the population or that serve as a habitat for organisms in the food chain.

7. MONITORING AND PERIODIC REVIEW OF THE SITE

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 nuclear 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 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 the type of data, the methodology for data collection, including the location and frequency of data collection, the necessary resolution and precision, data recovery requirements, as well as requirements for data processing and analysis.

7.3. Before commissioning of the nuclear installation begins, the background radioactivity of the atmosphere, hydrosphere, lithosphere and biota in the region shall be assessed so as to be able to determine the additional effects of the operation of the nuclear installation.

Requirement 29: Review of external hazards and site conditions

All external natural and human induced hazards and site conditions shall be periodically reviewed by the operating organization as part of periodic safety review and as appropriate throughout the operating lifetime of the nuclear installation, with due account taken of operating experience and new safety related information.

7.4. As part of periodic safety review or safety assessments under alternative arrangements, external natural and human induced hazards and site conditions shall be reviewed using 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) or-and in the event of any of the following:

- a) An update of the regulatory requirements;
- b) Indications of inadequate design against external hazards;
- c) New technical findings, such as the vulnerability of particular structure systems and components to any external hazards;
- d) New information, experience and lessons from the occurrence of actual external events affecting the safety of another nuclear installation or hazardous industrial facility;

- e) Changes of hazards over time for which new information and assessments have become available;
- f) A need to provide confidence that there are sufficient margins to prevent cliff edge effects;
- g) As part of a programme of long term operation, or in support of an application for a life extension.
- h) The development of new methods to analyse hazards that substantially improve earlier estimates.

7.5. If necessary, based on the outcome of the periodic review of site specific hazards or of data relevant for the radiological environmental impact assessment for the safe operation of the nuclear installation, the site specific hazards and/or the site conditions shall be re-evaluated.

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