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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 2015 as IAEA Safety Standards Series No. NS-R-3 Rev. 1. SSR-1 took into account and incorporates developments related to site evaluations for nuclear installations since the IAEA Safety Requirements NS-R-3/2003 and partially revised document NS-R-3 Rev. 1/2015 addressing overarching issues highlighted after the Fukushima Daiichi accident. It applies the Safety Fundamentals publication No. SF-1 on Fundamental Safety Principles Ref. [1]. Requirements for site evaluation are intended to ensure adequate protection of site personnel and the public and protection of the environment from the 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 Safety Guides on site evaluation listed in the references provide recommendations on how to meet the requirements established in this Safety Requirements publication.

OBJECTIVE

1.3. The objective of this publication is to establish appropriate requirements and criteria for:

- (a) Defining the extent of information on a site 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 design bases are defined according to the established performance criteria;
- (c) Analysing the characteristics of the population and the area surrounding the site with the aim to determine if there are insurmountable difficulties for planning to implement emergency response actions effectively.

The criteria described above are to be applied for:

- i. to identify the natural and human induced events external to the installation that are important to safety;
- ii. to 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 document addresses a broad range of nuclear installations as defined in Ref. [2].

1.6. Nuclear vessels propelled by nuclear reactors (e.g. submarines, ice breakers, etc.), and equipment for military use are excluded from the scope of this Safety Requirements document.

1.7. This Safety Requirements document covers site evaluation for both new and existing nuclear installations. Requirements for hazard evaluation are applicable to both categories. For the purpose of this Safety Requirements document, existing nuclear installations are those installations that are either (a) at the operational stage (including long term operation and extended temporary shutdown periods) or (b) at a pre-operational stage for which the construction of structures, manufacturing, installation and/or assembly of components and systems, and commissioning activities are significantly advanced or fully completed Ref. [2].

1.8. The site 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 GSR Part 7 Ref. [12]. This is typically the area within the security perimeter fence or other designated property marker.

1.9. The external human induced events considered in this Safety Requirements document are of accidental origin. Considerations relating to the physical protection of the installation against wilful actions by third parties are outside its scope.

1.10. The site selection process, also called 'siting processes, is divided into two stages Ref. [3]. The first stage is the site survey aiming to identify potential sites on the basis of existing data. In the site survey stage, large regions are investigated to find potential sites and to identify candidate sites. The second stage is aiming to select the site(s). In this second stage the candidate sites are assessed by screening and ranking to arrive at the 'preferred candidate sites'. The site evaluation process starts with the second stage of the siting process, following the site survey and shall continue throughout the entire lifetime site. The site characterization stage named also 'site assessment' has the objective to confirm the acceptability of the finally selected site, to complete the characterization of the site and to develop the site related design parameters of the nuclear installation. The pre-operational stage is usually developed during the design and construction of the nuclear installations and is aiming to perform confirmatory and monitoring activities of the design basis parameters established in previous stage. During the operation stage of the nuclear installation, confirmatory and monitoring activities of the design basis parameters are to be performed, as well as any full and comprehensive re-evaluation process as required by the periodic safety reviews.

1.11. This publication addresses the evaluation of those site related factors that have to be taken into account to ensure that the site–installation interactions does not constitute an unacceptable risk to individuals, the population or the environment over the lifetime of the installation. The non-radioactive aspects of the environmental impact assessment of site and installation are not explicitly covered in this document. An environmental impact assessment shall use of the collected site evaluation database in order to avoid inconsistencies in the analysis and reporting.

STRUCTURE

1.12. 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.

1.13. Section 2 of this document discusses the safety principles and concepts applicable to site evaluation. Section 3 discussed application of the management system for site evaluation. Section 4 provides 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. The Fundamental Safety Principles Ref. [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 radiation risk and for the safety of facilities and activities that give rise to radiation risk:

The fundamental safety objective is to protect people and the environment from harmful effects of ionizing radiation.

2.2. 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. It requires ensuring that nuclear installations are operated and activities are conducted so as to meet the highest standards of safety that can reasonably be achieved (see Ref. [1], para. 2.1). In this regard, 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 can 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. The fundamental safety objective applies for all facilities and activities and to all stages over the lifetime of a facility or radiation source, including planning, siting, design, manufacturing, construction, commissioning, and operation. This includes the associated transport of radioactive material and management of radioactive waste (see Ref. [1], para. 2.2).

2.4. This Safety Requirements publication establishes requirements that apply for implementation of the safety principles 8 and 9 as most relevant to be considered in site evaluation for nuclear installations (see Ref [1]). In this regard:

- a. The principle 8 says 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 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, and those characteristics of the site that can affect the interactions between the nuclear installation, the environment and the population in order to take into consideration the feasibility of planning to implement emergency action effectively in the region.

3. APPLICATION OF MANAGEMENT SYSTEM FOR SITE EVALUATION

Requirement 1: Application of the management system for site evaluation

Site evaluation shall be conducted and managed as part of management system.

3.1.A management system in compliance with GSR Part 2 Ref. [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 effectiveness of the execution of the site investigations and assessments, and engineering activities performed in the different stages of the site evaluation for the nuclear installation.

3.3.As part of a management system for the nuclear installation, the quality assurance for site evaluation shall be conducted and managed to comply with the national regulatory requirements.

3.4.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 can be graded in accordance with the importance to safety of the individual siting and site evaluation activity under consideration.

3.5.For each activity of the site evaluation process, including inspection, testing, verification and validation, the acceptance criteria and the responsibilities for carrying out these activities shall be specified and performed by designated individuals or groups other than those who originally performed the work.

3.6.The data collected 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.

3.7.Records shall be kept of the work carried out in the activities for site evaluation for the nuclear installation. Record retention times shall consider future reference needs by the organizations that will be responsible for the installation in all lifecycle phases.

4. GENERAL REQUIREMENTS FOR SITE EVALUATION

This section contains general requirements that are applicable to site evaluation process and 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 in terms of nuclear safety shall be to provide adequate input for demonstration of protection of the public and the environment from radiological consequences of radioactive releases due to accidents. Radioactive releases due to normal operation (i.e. discharges) shall also be considered.

4.1. The site evaluation process shall contain detailed acceptance criteria which are derived from safety objectives (see paragraph 2.2 and Ref. [1]). These criteria shall together contribute to demonstration of achieving the site safety objectives which address all stages of the project life time (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, population 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 accident conditions, including those that could warrant emergency response actions and external natural and human induced events that are important to safety.

4.3. Safety requirements for site evaluation apply to nuclear installations, with the use of a graded approach on the basis of the radiation risks that they pose to people and the environment.

4.4. The scope of the investigation for the site of a nuclear installation covers the entire process of the site evaluation. The requirements established in this publication do not apply to the site survey stage, for which a different series of criteria may be used.

USE OF THE GRADED APPROACH

4.5. This Safety Requirements publication covers nuclear installations, with the use of a graded approach on the basis of the radiation risk that they pose to people and the environment. The purpose of the graded approach principle is stated in IAEA SF-1 and defined in Ref. [2].

4.6. 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.

4.7. The level of detail needed in an evaluation to meet the requirements established in this publication will 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 detail. Requirements in this publication are stated to apply to nuclear installations using appropriate graded approach.

4.8. To screen out an installation from performing a formal site evaluation process, a formal screening process shall be applied for determining the need for the scope and depth of the site

evaluation process necessary to support the installation's safety case, which conservatively considers the potential radiological consequences of a release. Provided no unacceptable radiological consequences would be likely for workers or for the public or for the environment, and provided that no other specific requirements are imposed by the regulatory body for such an installation, the installation shall be screened out from following a formal site evaluation process.

4.9. For nuclear installations other than nuclear power plants where a graded approach is applied to site safety evaluation, the following shall be considered as applicable:

- 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 (e.g. nuclear chain reactions) and chemical processes (e.g. for fuel processing purposes) that take place at the installation.
- c) The thermal power of the nuclear installation;
- d) The configuration of the installation for activities of different kinds;
- e) The distribution and/or location of radioactive sources in the installation (e.g. for research reactors, most of the radioactive inventory will be in the reactor core and the fuel storage pool, whereas for fuel processing and storage facilities the radioactivity inventory is distributed throughout the installation);
- f) The changing nature of the configuration and layout for installations designed for experiments (such activities have an associated intrinsic unpredictability);
- g) The need for active systems and/or operator actions for the prevention of accidents and for mitigation of the consequences of accidents; characteristics of engineered safety features for the prevention of accidents and for mitigation of the consequences of accidents (e.g. the containment and containment systems);
- h) The characteristics of the processes or of the engineering features that can generate a cliff edge effect in the event of an accident;
- i) The characteristics of the site that are relevant to the consequences of the dispersion of radioactive material to the atmosphere and the hydrosphere (e.g. size, demography of the region);
- j) The potential for on-site and off-site contamination.

Requirement 4: Site suitability

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

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

- (a) The effects of external events occurring in the region of 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 zone in so far as they can affect the feasibility of planning to implement emergency response actions effectively as required in Ref. [12] and the need to evaluate the risk to individuals and to the population.

4.11. The site shall be deemed unsuitable for the location of selected 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.

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

4.13. 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.

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

4.15. For nuclear power plants, the total nuclear capacity to be installed at the site shall be determined as precisely as possible 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.

4.16. 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 considered 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.

4.17. 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 nuclear installation shall be identified and evaluated, according to their safety significance.

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

4.19. The size of the region to be investigated, also called 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, as tsunamis and volcanic

manifestations, near and far regions shall be considered for the potential hazards that can affect the safety of the nuclear installation.

4.20. The region shall be studied to evaluate the present and foreseeable future characteristics that can have an impact on nuclear safety including emergency preparedness and response. This includes distribution of the population in the region, the present and future use of land and water, 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: Screening of the site specific hazards

Potential hazards resulting from external natural phenomena and human induced events and activities which can realistically occur in the region of the site shall be identified through a screening process, evaluated and selected for design basis or re-evaluation purposes according to their significance to the safety of the installation.

4.21. 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 documented.

4.22. Events of high severity but low probability that could contribute to the overall risk shall be included in the site evaluation process. Also events of low severity but high probability that could contribute to the overall risk shall be included in the site evaluation process.

4.23. Screened out events on the basis of enveloping by other events shall ensure that all effects (e.g., load cases) are bounded.

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.

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

4.25. 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. Account shall be taken of uncertainties in the design basis hazard level.

4.26. The decision for using probabilistic or deterministic methodologies in hazard evaluation shall be based on the nature of the hazard, availability of data and type of application of the hazard to the installation 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.

4.27. Probabilistic hazard curves, in terms of accuracy level, probability range, and reference variables, when used, shall be developed with reference to the specific application (e.g. design, margin evaluation, probabilistic safety assessment, hazard monitoring, emergency planning, etc.).

4.28. Hazard assessments shall consider 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.

4.29. 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 either the projected design of the nuclear installation is not able to cope with and safely withstand the impact of external natural and human induced hazards defined as design basis during the early site evaluation stage, or resulted from the re-evaluation of the external natural and human induced hazards during the operating life.

4.30. During the execution of the early evaluation stage the projected design characteristics of the nuclear installation cannot be yet fully known, the need for protection of the site against the effects of specific phenomena of external natural and human induced hazards, defined for installation design basis, shall be evaluated considering that prevention and mitigation measures have to be duly taken in the design stage to ensure safety and that the safety of structures, systems and components of the nuclear installation to withstand some external natural and human induced hazards can be highly sensitive to potential “cliff-edge” effects.

4.31. 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 as unsuitable.

4.32. If either as a result of the evaluation performed according to para 4.23 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 categorized, designed, built, maintained and operated as important to safety related structures, systems and components.

Requirement 9: Site Evaluation for multi-installations at same site and collocated 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 collocated sites.

4.33. Occurrences of extreme external natural and human induced hazards and their credible combinations, which, are able to challenge the safety of multiunit or collocated sites and to generate disruptions of infrastructure affecting communications, transportation and utilities, shall be considered.

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.

4.34. The natural and human induced hazards affecting 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.

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

Requirement 11: Special considerations for the ultimate heat sink

The evaluation of site specific external and human induced hazards shall consider hazards that can impact availability and reliability of the ultimate heat sink.

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

- a) Air temperature, humidity;
- b) Water temperatures;
- c) Water quality characteristics including turbidity, suspended solids, and chemical and biochemical changes (natural or human induced);
- d) Available and sustainable flow of water (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.

4.37. 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. If the probabilities and consequences of such events cannot be reduced to acceptable levels, then the hazards for the nuclear installation associated with such events shall be established.

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

In site evaluation, to determine the potential radiological impact of the nuclear installation on the region for operational states and accident conditions 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.

4.38. The potential effects of the nuclear installation on population and environment shall be evaluated considering collocated installations (e.g. ‘multiple installation site’), their postulated accident scenarios (source terms) and infrastructures, and feasibility of planning 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.

4.39. 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 hit by the identified hazard scenarios.

4.40. The direct and indirect pathways by which radioactive material released from the nuclear installation can potentially affect people and the environment shall be identified and evaluated; in such an evaluation, specific regional and site characteristics and 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 external zone 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.

4.41. The requirements for site evaluation apply also to the infrastructure in and other characteristics of the external zone where emergency response actions may be warranted. The external zone for a proposed site shall be established with account taken of the potential hazards and associated consequences of an emergency involving the installation taking into account emergency planning zones expected to be established in line with Ref. [12]. Before construction of the installation is started, it shall be confirmed that there will be no insurmountable difficulties in developing and implementing an emergency plan for the external zone.

4.42. 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 Ref. [12]. The on-site and co-located installations shall be considered in the assessment, with special emphasis on nuclear installations that can experience concurrent accidents.

4.43. Causal relationship between external events and installation conditions shall be considered in evaluating the feasibility of planning to implement emergency response actions effectively.

4.44. 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 zone, is compliant with the site safety objectives.

Requirement 14: Data collection in site evaluation for nuclear installations

The necessary data needed to perform 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.

4.45. 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 life 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.

4.46. 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 population and environment.

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

- a) External natural and human induced hazards information: sources, propagation, potential effects on installation and workers, population and 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 potential impact of the installations on population and environment as a result of both normal operations as well as accident conditions;
- e) Information required for 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 in any environmental and installation conditions;
- g) Characteristics of site hazard monitoring, hazard alerts and periodic site re-evaluation conditions.

4.48. 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.

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

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

4.51. Prehistorical, 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.

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

4.53. Foreseeable significant changes in water and land use planning shall be considered in data collection, such as the expansion of existing installations and human activities or construction of new installations that can present significant hazard to the nuclear installation.

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 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 capability¹ shall be identified and evaluated. The evaluation shall consider the fault characteristics in the site vicinity. 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. 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.

5.4. 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.

Requirement 16: Ground motion hazard evaluation

The ground motion hazard evaluation shall be conducted to provide the input needed for the design or 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.

5.5. 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 Ref.[5].

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

5.7. Information on prehistorical, historical and instrumentally recorded earthquakes in the region shall be used in hazard assessment and properly documented.

¹ 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 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 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.

5.8.A thorough uncertainty analysis of the methods and input data shall be performed as part of the evaluation of seismic hazard assessment.

5.9.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.

5.10.Capable volcanos² 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 [Ref. 6].

5.11.The hazards of capable volcanoes 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 deterministic and/or probabilistic safety analyses performed during the lifetime of the installation.

5.12. For the new sites, an alternative site shall be considered 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 through design and site protection measures.

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

5.14.The effect of volcanic phenomena shall be considered in combination with other volcanically induced hazards.

METEOROLOGICAL HAZARDS

Requirement 18: Extreme meteorological hazards evaluation

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

5.15.Meteorological hazards such as wind, precipitation, snow and ice, air and water temperature, humidity, storm surges and sand / dust storms shall be evaluated for their extreme values based on available documentation for an appropriate period of time Ref. [7].

5.16.An appropriate meteorological model shall be developed to evaluate the quantity of the data, the length of the historical period over which the data were accumulated, and known past changes in relevant characteristics of the region.

Requirement 19: Rare meteorological hazards evaluation

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

² 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.

Lightning

5.17. 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

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

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

Cyclones

5.20. The potential for the occurrence, frequency and severity of cyclones and associated missiles shall be evaluated in the region of interest, together with the hazard posed by these phenomena, on the basis of the available data and the appropriate physical models.

FLOODING EVENTS

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

5.21. The potential for flooding in the region due to one or more natural causes (including in combination) such as runoff resulting from precipitation or snow melt, high tide, storm surge, seiche and wind waves, as well as climate change, which can affect the safety of the nuclear installation shall be evaluated Ref. [7].

5.22. An appropriate meteorological and hydrological model shall be developed to derive the flooding hazard for the site, including secondary effects such as debris, ice, sediment, etc.

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

5.24. The flood hazard assessment shall be conducted using appropriately supporting numerical models, and shall adequately consider the uncertainties.

5.25. 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

5.26. 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.

5.27. 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 runup³ that can result in physical effects on the site.

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

5.29. The potential for tsunamis or seiches to be generated by regional offshore seismic events shall be evaluated on the basis of known seismotectonic characteristics. If the tsunami-genic source is not characterized sufficiently, conservative tsunami-genic source parameters shall be taken into account.

Floods and waves caused by failure of water control structures

5.30. The upstream water control structures shall be analysed for screening purposes to determine potential hazard to the nuclear installation resulting from the failure of one or more of the upstream structures, including in combination with flooding from other causes. Water control structures can be screened out from further analysis if it can be demonstrated that the nuclear installation can safely withstand the effects of the massive failure of the upstream structures.

5.31. If a preliminary examination of the nuclear installation indicates that it cannot 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 including such effects; otherwise such upstream structures shall be upgraded to withstand the hazards associated with the nuclear installation.

5.32. Flooding and associated phenomena caused by storage of water as a result of blockage of rivers up or downstream (e.g., caused by landslides or ice) or 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

5.33. 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 considered Ref. [8].

³ Draw-down is a lowering of the water level at a coastal site. Runup is a sudden surge of water up a beach or a structure.

5.34. 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

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

5.36. Geological maps and other appropriate information for the region shall be examined for the existence of natural features such as caverns, karstic formations and human made features such as mines, water wells and oil wells. In subduction zone, tectonic deformation also shall be considered. The potential for collapse, subsidence or uplift of the site surface shall be evaluated for loading conditions over the life time of the nuclear installation.

Soil liquefaction

5.37. 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.

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

Requirement 22: Geotechnical characteristics of subsurface materials

The geotechnical characteristics of the subsurface materials shall be investigated.

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

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

5.41. The groundwater regime and the chemical properties of the soil and groundwater shall be studied and accounted for.

OTHER NATURAL HAZARDS

Requirement 23: Evaluation of other natural hazards

In addition to natural hazard requirements 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.

5.42. Other natural external hazards like wild-fires, drought, hail, sub-surface freezing of subcooled water (frazil), blockage or diversion of a river shall be considered. If the potential of challenging the safety of nuclear installation is confirmed, the hazard shall be assessed and design bases for these events shall 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.

5.43. The human induced events to be considered shall include, but shall not be necessarily limited to, the hazards due to collisions from land, sea or air transport, fire, explosions from stationary sources or land or sea transport or pipelines, release of hazardous gases to the site and electromagnetic interference Ref. [9].

5.44. Industrial activities and events in the region around the installation shall be investigated, including resource extraction activities, manufacturing, waste disposal, land reclamation and other significant re-contouring of land or water.

5.45. The relevant information shall be obtained and evaluated on the stationary and mobile sources of hazard up to a conservatively established distance within which the source can have the possibility of adversely affecting the safety of the nuclear installation including as forecasted over the lifetime of the installation.

Aircraft crashes

5.46. 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.

5.47. The hazards associated with an identified potential for an aircraft crash on the site that can affect the safety of the installation shall be evaluated, including consideration of impact, fire, missiles and explosions.

Chemical hazards

5.48. 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 considered.

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

Other human induced events

5.50. The region shall be investigated for installations (including collocated units of nuclear power plants and installations such as co-located nuclear installations) in which flammable, explosive, asphyxiant, toxic, corrosive or radioactive materials are stored, processed, transported and otherwise dealt with that, if released under normal or accident conditions, can jeopardize the safety of the installation. This investigation shall also include installations that can give rise to missiles of any type that can affect the safety of the nuclear installation.

5.51. The potential effects of electromagnetic interference shall also be evaluated and considered in the design and/or safety assessment.

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 (see Ref. [10]).

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 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 prior to submittal of the site evaluation report shall be collected and used in the analyses, together with any other relevant data that can be available from other sources.

6.3. On the basis of the data obtained from the investigation of the region, the atmospheric dispersion of radioactive material potentially released shall be evaluated.

Dispersion of radioactive material through surface water

6.4. 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.

6.5. A description of the surface hydrological characteristics of the region (including interaction with 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.

6.6. A programme of investigation and measurements of the surface hydrology 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 reconcentration ability of sediments and biota, and the determination of transfer mechanisms of radionuclides in the hydrosphere and along exposure pathways.

6.7. Assessment of the potential impact of the contamination of surface water shall be performed using collected data and information in a suitable model.

Dispersion of radioactive material through groundwater

6.8. 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.

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

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

Requirement 26: Population distribution

The distribution of the population within the region over the lifetime of the installation shall be determined.

6.11.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. The radius within which information is needed shall be chosen on the basis of potential consequences, with account taken of special situations. Special attention shall be paid to the population living in the immediate vicinity of the installation, densely populated areas and population centres in the region, sensitive populations, and institutions such as schools, hospitals and prisons.

6.12.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.

6.13.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.

6.14.The investigation shall cover land and water bodies that are used by the population or serves as habitat for organisms in the food chain.

7. MONITORING AND PERIODIC RE-EVALUATION OF THE SITE

This section provides requirements for monitoring of hazards and periodic reassessment of site related hazards and conditions that can affect safety over the entire lifecycle 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 characteristics of natural and human induced hazards as well as the demographic, meteorological and hydrological conditions of relevance to the nuclear installation shall be monitored over the lifetime of the nuclear installation.

7.3. 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.

7.4. Baselines for each of the external natural and human induced hazards and site conditions that are defined in the monitoring plan shall be established on basis of the results of the monitoring performed in each phase of the installation lifecycle (construction, commissioning and operation), before the initiation of the next phase.

7.5. 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 nuclear installation operation.

Requirement 29: Reassessment of external hazards and site conditions

All external natural and human induced hazards and site conditions that are covered in this document 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.

7.6. As part of safety reviews such as periodic safety reviews or safety assessments under alternative arrangements (Ref. [11]), external natural and human induced hazards shall be reassessed 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) Update of the regulatory requirements, that take into account the 'state of knowledge' and the actual as-is condition of the installation;
- (b) Inadequate design against external hazards, generally due to the vintage of the facility;

- (c) New technical findings, such as 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 safety of nuclear installations;
- (e) Changes of hazards with the time, for which new information and assessment are available;
- (f) The need to address the issue of performance of the installation for some beyond design basis external events in order to provide confidence that there are sufficient margins to prevent ‘cliff edge effects’;
- (g) A programme of long term operation, or life extension programme, of which such an evaluation is a part.

7.7. The implications of such a reassessment of site specific hazards for the safe operation of the nuclear installation shall be evaluated periodically including the comparison with the original design basis and the need to establish new re-evaluation basis.

7.8. Site conditions and characteristics that are relevant to the radiological impact on the environment produced by the installation operation shall be also periodically reassessed as part of periodic safety reviews of the nuclear installation, in a systematic and comprehensive manner and using new data and information as well as the operating experience and the respective results of the monitoring programme implemented until the reassessment date.

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