NSN-06
Nuclear safety regulation on the protection of nuclear installations against external events

Revised in the frame of "Regional Excellence Project on Regulatory Capacity Building in Nuclear and Radiological Safety, Emergency Preparedness and Response in Romania", 2014-2017

Chapter I - Domain, scope, definitions, nuclear safety objectives

Section 1

Domain and scope

Art. 1. – (1) This regulation is issued in accordance with the provisions of the Law no. 111/1996, on the safe deployment, regulation, licensing and control of nuclear activities, with subsequent modifications and completions.

(2) This regulation establishes the general nuclear safety requirements for the protection of nuclear installations against external events.

(3) Compliance with this regulation is a necessary condition for the licensing, by the National Commission for Nuclear Activities Control (CNCAN), of the siting, construction, commissioning and operation of a nuclear installation.

(4) This regulation is applicable both to license applicants and to licensees for the phases of siting, construction, commissioning and operation of a nuclear installation.

(5) In the licensing process, as well as for the whole duration of the validity of a license, CNCAN may impose supplementary requirements, as the case may be, for taking account of the accumulated experience, review and assessment activities, research activities and the newest standards and good practices recognized at international level.

Art. 2. – (1) This regulation is applicable to the following categories of nuclear installations:

a) nuclear power plants;

b) research reactors;

c) demonstration reactors;

d) nuclear fuel fabrication plants;

e) spent nuclear fuel storage installations;

f) other nuclear installations for which CNCAN considers as necessary the application of this regulation in the licensing process.

(2) Except as specified otherwise, this regulation is applicable in a technology-neutral manner.

(3) Any exemption from the application of the requirements of this regulation shall require approval by CNCAN, based on written justification, issued in writting by the applicant of licensees, if it demonstrates the assurance of nuclear safety provisions equivalent to the ones required by this regulation, taking account of the risks associated with the respective installation.

Section 2

Definitions

Art. 3. – (1) The terms used in this regulation are defined in Annex 1, except for those defined in the text of the regulation.

(2) The abbreviation SSCE is used for making reference, in a generic manner, to the systems, structures, components and equiment of the nuclear installation.

(3) The abbreviation EENO is used for making reference, in a generic manner, to the external events of natural origin.

(4) The abbreviation HIEE is used for making reference, in a generic manner, to the human induced external events.

Section 3

Nuclear safety objectives

Art. 4. – (1) The evaluation of external events, of their probability of occurrence and of their consequences, shall be an integral part of the safety evaluation for a nuclear installation.

(2) Threats from external events shall be eliminated or minimised as far as reasonably practicable, for all operational states of the nuclear installation.

(3) The nuclear safety evaluation for external events shall include the assessments of the design basis events and of the conditions that exceed the design basis, with the aim to identify needs and opportunities for improvement.

Chapter II - Requirements regarding the protection against external events of natural origin

Section 1

Identification of the EENO

Art. 5. – (1) All EENO (external events of natural origin) that could affect the site of the nuclear installation shall be identified, together with any events that could be generated by these.

(2) The applicant / the licensee shall demonstrate that the list of EENO identified is completed and relevant for the site of the nuclear installation.

Art. 6. – (1) The list of potential EENO shall include the following categories of events:

a) Seismotectonic hazards;

b) Hydrological hazards;

c) Meteorological hazards;

d) Biological phenomena;

e) Geological hazards;

f) Vegetation fires.

(2) A detailed list of EENO is provided in Annex 2. The list is provided for illustration purposes and is not exhaustive.

Section 2

Selection and evaluation of EENO

Art. 7. – (1) A preliminary evaluation shall be performed for all EENO that could affect the site, to estimate de probability of occurrence and the consequences for the nuclear installation. This preliminary evaluation involves the systematic characterization of all hazards due to external events.

(2) For all EENO credible for the site and which could physically affect the nuclear installation, a detailed evaluation shall be performed. From the EENO that could affect the site, the following events can be excluded from the detailed evaluation:

a) the events which do not have the capability to physically affect the installation and / or the fulfillment of the nuclear safety functions and

b) the events for which it can be demonstrated, with a high degree of confidence that their probability of occurrence is very low or that they are physically impossible to occur.

(3) The combinations of events which have the potential to affect the nuclear installation shall be evaluated. Even if certain events could be excluded on an individual basis, the credible and relevant combinations of events shall be included in the nuclear safety evaluation. Such combinations of events may include combinations of one or more EENO, as well as combinations of EENO and internal events or human induced events. The evaluation shall consider successions of events and combinations of causally linked events, as well as combinations of independent events that have relatively high individual frequencies of occurrence.

(4) The selection (screening) process for the events and event combinations shall be based on conservative assumptions.

(5) Assessments, verifications and inspections on site and in the installations shall be performed for confirming the assumptions used in the selection process.

(6) The criteria and arguments at the basis of the selection (screening) process shall be justified.

Section 3

Hazard analysis

Art. 8. – (1) Detailed hazard analyses shall be performed for all EENO that have been selected in accordance with the requirements in art. 7. These analyses are aimed at the identification and characterization of the hazards, existent or potential, as well as of their effects on the nuclear installations on a given site, for the purpose of deriving inputs to be used in the design and in the safety evaluations

(2) The hazard analysis shall use deterministic and probabilistic methods, taking into account the current state of science and technology with regard to the data, instruments and analysis methods.

(3) The hazard analyses shall take into account all the relevant data available and shall establish a relation between the severity of the external events and the annual probability of exceedance, where practicable. Also, the maximum credible hazard severity shall be determined for each event, where this is practicable.

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

Art. 9. - (1) The hazard analyses shall be based on all the relevant data for the site and for the respective region, for an area sufficiently large to ensure that all external events that may impact the site are considered in the analysis. An extrapolation of the available data shall be performed to include events that exceed those from the recorded data and historical data. (2) In the determination of hazards, site specific data shall be used, unless such data are unobtainable. In this case, data from other regions that are sufficiently relevant to the region of interest may be used in the determination of hazards. Appropriate and acceptable simulation techniques may also be used. In general, data obtained for similar regions and simulation techniques may also be used to augment the site specific data.

3) The events the severity of which could vary during the lifetime of the nuclear installation shall be evaluated in a conservative manner. The evolution of these events shall be monitored for the whole lifetime of the nuclear installation and the hazard analyses shall be updated accordingly.

4) The methods and assumptions used in the hazard analyses shall be justified.

5) The uncertainties that can affect the hazard analyses shall be evaluated.

Section 4

Definition of the design basis events

Art. 10. - The license holder shall define the design basis EENO taking into account the site specific hazard analyses. The design basis EENO can be individual events or combinations of independent or causally linked events. The design basis may be the original design basis of the nuclear installation or a reviewed design basis, as for example in the framework of the periodic safety review process. *Proposed reformulation by consultants: or the design basis, as it is used, for example, in the framework of the periodic safety review / or as revised as an outcome of the periodic safety review. Alternative: reevaluated design basis.*

Art. 11. – (1) The annual probability of exceedance of the design basis EENO shall be low enough to ensure, with a high degree of confidence, the protection against external events of natural origin.

(2) For each design basis EENO, a target value shall be used for the annual probability of exceedance, not higher than 1E-4 events/year. Where it is not possible to calculate this probability with an acceptable degree of certainty, a design basis event shall be chosen and justified to reach an equivalent level of protection.

(4) The target value specified in para. (2) does not apply to nuclear installations for which the applicants / licensees demonstrate that for such events there can be no off-site consequences in excess of the legal dose limits for the members of the public.

Art. 12. – The design basis EENO shall be compared to relevant historical and prehistorical data to verify the way in which the historical and prehistorical extreme events are enveloped, with sufficient safety margins, by the design bases of the nuclear installation.

Art. 13. – Design basis parameters shall be defined for each design basis EENO taking account of the results of the hazard analyses. The design basis parameter values shall be established on a conservative basis.

Section 5

Protection against design basis events

Art. 14. – (1) The protection of the nuclear installations against the design basis EENO shall be ensured. A strategy for the protection against EENO shall be established, as a basis for the design of the corresponding measures.

(2) The protection strategy shall be established such that it ensures, with sufficient demonstrated reliability and with adequate margins, that the safety functions can be fulfilled for any direct or indirect credible effects of the design basis EENO.

Art. 15. – The strategy for the protection against design basis EENO shall:

(a) provide sufficient safety margins, in a conservative manner, in the design of the nuclear installation;

(b) rely primarily on passive measures as far as reasonable practicable;

(c) ensure that measures to cope with design basis accidents remain effective during and following design basis EENO;

(d) take into account the predictability and development of the EENO over time;

(e) ensure that the necessary procedures and means are available to verify the plant condition during and following design basis EENO;

(f) consider that events could simultaneously challenge several redundant or diverse trains of a safety system, multiple SSCE or several units at multi-unit sites, site and regional infrastructure, external supplies and other countermeasures;

(g) ensure that sufficient resources remain available at multi-unit sites considering the use of common equipment or services;

(h) not adversely affect the protection against other design basis events (not originating from natural hazards).

Art. 16. – The SSCE identified as having a role in the implementation of the strategy for protection against EENO shall be considered SSCE with nuclear safety functions.

Art. 17. – Monitoring and warning processes shall be available to support the protection strategy against design basis EENO. Wherever possible, threshold values shall be defined for the prompt initiation of protection measures. Also, threshold values shall be defined for the initiation of the planned measures for the verification of the condition of the nuclear installation following the occurrence of the EENO.

Art. 18. – The license holder shall implement measures for ensuring the availability of staff working in shifts, of the staff that provides technical and logistical support, as well as the availability of the equipment and materials necessary for the management of the situations caused by EENO with long-lasting effects, which could affect the normal operation of the nuclear installation and of the associated work processes.

Section6

Considerations for events more severe than the design basis events

Art. 19. – For the extension of the design bases / for the analysis of conditions that exceed

the design basis, EENO more severe than those considered in the design basis shall be identified and selected. Alternative: *EENO more severe than those considered in the design basis shall be identified and selected for the purpose of conducting an analysis of the conditions that exceed the design basis, to identify practicable improvements for increasing the robustness of the nuclear installation against such events*.

Their selection shall be justified based on deterministic and probabilistic analyses and on engineering judgement.

Art. 20. – (1) To support the identification of EENO which exceed the design bases and for the evaluation of their effects, hazard curves shall be developed, where practicable, to present the severity of the events as a function of their annual probability of exceedance or of other relevant parameters.

(2) The detailed analysis of EENO more severe than the design basis events is not necessary if it can be demonstrated with a high degree of confidence that their contribution to the risk is acceptably low.

Art. 21. – The analysis of the EENO which exceed the design bases and the identification of the practicable measures for increasing protection against these events shall include the following, as far as practicable:

(a) demonstration of sufficient margins to avoid "cliff-edge effects" that would result in the loss of a safety function;

(b) identification and assessment of the most adequate means for ensuring the fundamental safety functions;

(c) consideration of the events that could simultaneously challenge the redundant or diverse trains/sub-systems of a safety system, multiple SSCE or several nuclear installations on the same site, the site and regional infrastructure, the availability of technical and logistical support from off-site and other countermeasures;

(d) demonstration of the availability of sufficient resources for the sites on which several nuclear installations are located, taking into consideration the sharing of equipment and services;

(e) verifications and inspections on site and in the installations, for confirming the assumptions used in the analysis of the events and combinations of events considered, as well as the robustness of the protection measures provided.

Section 7

Specific considerations for protection against seismic events

Art. 22. – Seismic Hazard Assessment

(1) The seismic ground motion at the site shall be based on a site-specific seismic hazard analysis (existing or new) that reflects the curent international recognized state of practice including deterministic and probabilistic methods.

(2) Comprehensive up-to-date data shall be compiled that include geological, seismological, and geophysical data; local site topography; and surficial geologic and geotechnical site properties. A catalog of historical, instrumental, and paleoseismicity information shall also be compiled.

(3) The hazard analysis shall examine all credible sources of potentially damaging earthquakes.

(4) Uncertainties in each step of the hazard analysis shall be propagated and displayed in the final quantification of hazard estimates for the site.

(5) When use is made of an existing study for seismic hazard analysis, it shall be confirmed that the basic data and interpretations are still valid in light of current information.

(6) The spectral shape shall be based on a site-specific evaluation. A horizontal peak ground acceleration value of 0.1g shall be considered, as a minimum, even if its exceedance frequency would be below the target value specified at Art 11 para. (2).

(7) In addition to the vibratory ground motion, other seismic hazards, such as fault displacement, landslide, soil liquefaction, or soil settlement, should be addresed.

Art. 23. – Seismic Design and Qualification

(1) The design of the plant shall provide adequate margin of safety against seismic hazard and avoiding cliff edge effects.

(2) The design of the plant shall provide for an adequate margin of safety against seismic induced large radioactive release that would trigger the activation of offsite emergency measures.

(3) All items important to safety shall be identified and shall be classified on the basis of their function and their safety significance. Seismic qualification for items important to safety shall be implemented to ensure that they are capable of performing their intended safety functions.

(4) The engineering design rules for items important to safety shall be specified and shall comply with the relevant national or international nuclear codes and standards and with proven engineering practices.

(5) For nuclear power plants and research reactors the following shall be established:

a) the values of the parameters of the seismic motion for which it is necesary to shut down the reactor, after the earthquake, for performing the inspections and verifications for evaluating the impact on the installation and for having assurance that operation can be resumed in safe manner; *(non-exceedance or small exceedance of SL1/SDE).*

b) the values of the parameters of the seismic motion for which it is necesary to shut down the reactor, in response to a seismic and inspect for potential damages *(significant excedance of SL1/SDE but less than SL2/DBE).*

Art. 24. – Seismic Margin Evaluation

(1) A Review Level Earthquake (RLE) characterized by a ground motion spectrum shall be selected consistent to the target seismic margin and considering cliff edge effect.

(2) For NPPs a minimum of two diverse success paths shall be developed consisting of Structures Systems and Components (SSCE) that can be used to bring the plant to a safe stable state.

(3) Seismic responses calculated for the review level earthquake shall be median centered, shall be based on current state-of-the-art methods of structural modeling (e.g. best estimate of material damping, strength, ductility, etc.), and shall include the effects of soil-structure interaction where applicable.

(4) The screening of components and subsequent seismic margin calculations shall incorporate the findings of a detailed walkdown of the plant focusing on the anchorage, lateral seismic support, and potential spatial interactions.

(5) Seismic margin calculations shall be performed for critical failure modes of SSCE such as structural failure modes and functional failure modes identified through the review of plant design documents, including analysis and test reports, and the results of a plant walkdowns.

(6) The calculation of seismic margins, e.g. high confidence of low probability of failure (HCLPF) capacities, shall be based on plant-specific data supplemented by earthquake experience data. Use of such generic data shall be justified.

(7) The plant seismic margin shall be reported based on the margins calculated for the success paths.

Chapter III - Requirements regarding the protection against human induced external events

Section 1

General considerations

Art. 25. – (1) All external, non-malevolent, HIEE that could affect the site of the nuclear installation, together with any events that could be generated by these, shall be identified based on a systematic approach, to provide data for the design basis parameters of safety-related SSCE.

(2) The applicant / the licensee shall demonstrate that the list of HIEE identified is completed and relevant for the site of the nuclear installation. (3) The data on HIEE in the region of the site shall be collected and updated during the whole lifetime of the nuclear installation and

shall be used in the periodic safety reviews.

Art. 26. – (1) Human - induced external events to be considered and assessed by the applicant / licensee shall include at least the following categories of events:

a) Airplane crashes;

b) Other transportation events;

c) Events due to industrial activities in the vicinity of the site, e.g. missiles, gas clouds, fires, explosions, etc.;

d) Electromagnetic interference;

e) Fires on the site.

(2) The criteria for the selection of HIEE considered in the design shall be justified.

Art. 27. – (1) The effects of the HIEE shall be analzyed. A non-exhaustive list of potential effects of HIEE in provided in Annex 3.

(2) The impact of these effects on the nuclear installation shall be analyzed. The potential effects on emergency plan execution, including effects on evacuation routes, shall also be considered. The effects that could render off-site power supplies unavailable shall also be taken into account.

(3) For all HIEE credible for the site and which could physically affect the nuclear installation, a detailed evaluation shall be performed for the purpose of deriving inputs to be used in the design and in the safety evaluations.

Art. 28. – (1) Monitoring and warning processes shall be available to detect HIEE and alert the licensee's organization.

(2) Specific operational procedures shall be set up for operator action following an accident caused by an external human induced event.

Section 2

Aircraft crashes

Art. 29. – (1) The potential for aircraft crashes on the site shall be assessed with account taken, to the extent practicable, of characteristics of future air traffic and aircraft types. A study shall be made of airports and their takeoff, landing and holding patterns, flight frequencies and types of aircraft. Air traffic corridors and no-flight zones shall also be taken into account.

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

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

(4) Emergency response procedures shall be established to cope with an aircraft crash event on the site, including with the effects of potential fires and explosions. For this purpose, the licensee shall perform a design-specific assessment of the effects on the facility of the impact of a large, commercial aircraft, using realistic analysis. The assumptions and assessment methods shall be justified.

Section 3

Transportation Hazards

Art. 30. – (1) Present and proposed land and water transportation routes in the region shall be evaluated with respect to potential impact to safety-related SSCE, generation of explosions, chemical and radiological hazards and fires.

(2) The conveyance of hazardous materials by sea or inland waterways, railway rolling stock and road traffic, together with their loads shall be taken into account.

Section 4

Chemical and Radiological Hazards

Art. 31. - (1) All chemical and radiological hazards in the region, including on the site, that could affect the safe operation of the nuclear installation shall be identified and evaluated, with particular focus on activities that involve the handling, processing, and storage of radioactive materials, volatile and reactive gases, corrosive chemical substances and toxic or asphyxiant chemicals.

(2) The effects of the chemical and radiological hazards on SSCE and unprotected personnel shall be analyzed, including estimates of overpressure, toxicity, and transport characteristics in air.

Section 5

Electromagnetic Interference

Art. 32. – (1) Electromagnetic emitters in the region shall be evaluated during normal and abnormal operations with respect to their potential to affect the safe operation of the nuclear installation.

(2) Emitters subject to evaluation shall include the following:

a) Telecommunications facilities, including military and civilian radar installations;

b) Particle accelerators or other research facilities utilizing large electromagnetic fields;

c) High-voltage transmission lines.

(3) The potential effects of electromagnetic interference and eddy currents in the ground shall also be evaluated.

(4) Design and administrative provisions shall be implemented to protect the nuclear installation against the effects of electromagnetic interferences.

Section 6

Fires and Explosions

Art. 33. – (1) All potential fire and explosion events in the region that could affect the safe operation of the nuclear installation shall be evaluated, including:

a) amplitude, time/duration/transient and direction of pressure waves and their effects on SSCE and unprotected personnel;

b) temperature effects on SSCE and unprotected personnel;

c) potential secondary fires and explosions generated by the primary explosion or fire.

(2) Design and administrative measures shall be implemented to protect the nuclear installation against the effects of fires and explosions.

Chapter IV - Considerations for long term heat removal

Art. 34. – For nuclear reactors, in the design of systems for long term heat removal from the core, site related parameters and their variations, including the following, shall be considered:

a) Extreme air temperature and humidity;

b) Extreme water temperatures;

c) Available flow of water, minimum water level and the period of time for which safety related sources of cooling water are at a minimum level, with account taken of the potential for failure of water control structures.

Art. 35. – (1) Potential natural and human induced events that could cause a loss of function of systems required for the long term removal of heat from the core shall be identified, such as:

a) the blockage or diversion of a river;

b) the depletion of a reservoir;

c) an excessive amount of marine organisms;

d) the blockage of a reservoir or cooling tower by freezing or the formation of ice;

e) collisions of ships or floating debris, e.g. ice, logs, with accessible safety related structures, such as water intakes and ultimate heat sink components;

f) oil spills and fires.

(2) The hazards associated with such events shall be analyzed and adequate design and administrative measures shall be implemented to cope with such events and maintain the heat removal safety function.

Chapter V - Transitory and final provisions

Art. 36. – (1) The applicant / licensee shall demonstrate the implementation of all necessary measures, at the level of the newest standards and good practices recognized at international level, for ensuring protection of the nuclear installations against external events.

(2) The reference documents in Annex 4 represent standards and guides regarding good practices recognized at international level and it is recommended that any new revision of these is taken into account by the license holder for improving the protection of the nuclear installations against EENO.

(3) The licensee shall use regional and international experience with regard to external events and their effects in order to update and improve its safety assessments and its operational and emergency response procedures.

Art. 37. – For the nuclear installations which on the date of the entry into force of this regulation are in the phases of construction, commissioning or operation, the reconfirmation of the design bases shall be an integral part of the licensing process specific to the respective phases and shall be documented in the corresponding safety analysis reports. For these installations, the evaluation against the requirements in this regulation shall be performed in accordance with the principles applied to the periodic safety review established in the regulations issued by CNCAN.

Art. 38. – In 1 year from the entry into force of this regulation, the license holders for nuclear installations in the operational phase shall submit to CNCAN for review a report presenting the following:

a) an analysis of the compliance with the requirements in this regulation;

b) the plan with corrective actions and compensatory measures necessary for the fulfillment of requirements in this regulation.

Art. 39. – (1) Annexes 1, 2, 3 and 4 are an integral part of the regulation.

(2) Any provision contrary to those of the present regulation shall be abrogated on the date of the entry into force of this regulation.

ANNEX 1

Definitions

Design basis accident - any accident taken into account in the design basis for the nuclear installation.

Cliff-edge effect - in the nuclear safety analysis it represents any situation in which a relatively small variation of the input data for the analysis leads to a disproportionately large variation in the results regarding the behaviour of a nuclear installation, in the sense of the worsening of the conditions; in what regards the behaviour of a nuclear installation, a cliff-edge effect represents any situation in which a small deviation of a parameter of the nuclear installation produces a disproportionately abnormal behaviour of the installation, such as, for example, a transition between a normal state of operation to an accident state or a transition from design basis accident conditions to conditions beyond the design bases.

Design basis event - represents any event or combination of events that gives the basis for the selection of the design parameters for a certain system, equipment or structure of a nuclear installation, credited in the safety analyses as contributing to the limitation of the radiological consequences of a transient or accident.

External events - Events unconnected with the operation of a facility or activity that could have an effect on the safety of the facility or activity.

Nuclear safety function - a specific purpose that has to be fulfilled to ensure nuclear safety. The general nuclear safety functions are the following:

a) reactivity control; for a nuclear reactor, this function includes the shutdown of the reactor and the maintaining of the reactor in a safe shutdown state for an indefinite period of time;

b) cooling of the nuclear fuel;

c) retention/confinement of the radioactive materials, including maintaining the physical barriers that prevent their release to the environment;

d) monitoring of the state of the nuclear installation and providing the support services necessary for maintaining the functions mentioned at a), b) and c).

ANNEX 2

Non-Exhaustive List of External Events of Natural Origin

1) Seismotectonic (earthquake)

a) Vibratory ground motion (including aftershock effects)

b) Long period ground motion

c) Vibratory ground motion induced or triggered by human activi-ty (oil, gas or groundwater extraction, mine collapses)

d) Surface faulting (fault capability)

e) Liquefaction, lateral spreading

f) Dynamic compaction (seismically induced soil settlement)

g) Permanent ground displacement subsequent to earthquake

2) Hydrological hazards

a) Tsunami (seismic, volcanic, submarine land sliding, meteorite impact) including drawdown

b) Flash flood: flooding due to local extreme rainfall (note links to other meteorological phenomena)

c) Floods resulting from snow melt

d) Flooding due to off-site precipitation with waters routed to the site (including river floods)

e) High ground water

f) Flood due to obstruction of a river channel (downstream or upstream) by landslides, ice, jams caused by logs or debris, or volcanic activity)

g) Flood resulting from changes in a river channel due to erosion or sedimentation, river diversion

h) Flood resulting from large waves in inland waters induced by volcanoes, landslides, avalanches or aircraft crash in water basins

i) Flood and waves caused by failure of water control structures and watercourse containment failure (dam failure, dike failure) due to hydrological or seismic effects

j) Seiche

k) Bore (tide-induced and induced by water management)

l) Seawater level: high tide, spring tide

m) Seawater level, lake level or river: wind generated waves

n) Seawater level: storm surge

o) Seawater level: impact of human made structures such as tide breaks and jetties

p) Corrosion from salt water

q) Instability of the coastal area due to erosion or sedimentation (sea and river)
r) Underwater debris

3) Meteorological events: Extreme values of meteorological phenomena

a) Precipitation (rain or snow), snow pack
b) Extremes of air temperature (high and low)
c) Extremes of ground temperature (high and low)
d) Extremes of cooling water (sea, lake or river) temperature (high and low)
e) Humidity (high and low), extreme atmospheric moisture
f) Extremes of air pressure
g) Extreme drought leading to low river or lake water levels
h) Low ground water
i) Low seawater level
j) Icing (including for power lines)
k) White frost
l) Hail
m) Permafrost
n) Recurring soil frost
o) Meteorological events: Rare meteorological phenomena
p) Lightning (including electromagnetic interference)
q) High wind, storm (including Hurricane, Tropical Cyclone, Ty-phoon)
r) Tornado
s) Waterspout (tornadic waterspout)
t) Blizzard, snowstorm
u) Sandstorm, dust storm
v) Salt spray, salt storm
w) Wind blown debris (external missiles)
x) Snow avalanche
y) Surface ice on river, lake or sea
z) Frazil ice
aa) Ice barriers
bb) Mist, fog, freezing fog
cc) Solar flares, solar storms, electromagnetic interference

4) Biological / Infestation

a) Marine/river/lake growth (seaweed, algae), biological fouling
b) Crustacean or mollusk growth (shrimps, clams, mussels, shells)
c) Fish, jellyfish
d) Airborne swarms (insects, birds) or leaves
e) Infestation by rodents and other animals
f) Biological flotsam (wood, foliage, grass etc.)
g) Microbiological corrosion

5) Geological

a) Slope instability (landslide, rock fall; including meteorologically and seismically triggered events)
b) Underwater landslide, gravity flow (including seismically trig-gered events)
c) Debris flow, mud flow (including seismically triggered events)
d) Ground settlement (natural or man-made; mining, ground wa-ter extraction, oil/gas production)
e) Ground heave
f) Karst, leeching of soluble rocks (limestone, gypsum, anhydrite, halite)
g) Sinkholes (collapse of natural caverns and man-made cavities)
h) Unstable Soils (quick clays etc.)
i) Volcanic hazards: phenomena occurring near the volcanic cen-tre
j) Volcanic hazards: effects extending to areas remote from the volcanic centre (ash clouds)
k) Methane seep
l) Natural radiation
m) Meteorite fall (includes other effects than seismic)

6) Vegetation fires

a) Forest fire, wildfire, burning turf or peat

ANNEX 3

Non-exhaustive list of effects of Human-Induced External Events

These potential effects of HIEE include the following:

a) air pressure wave and wind;

b) projectile impact;

c) heat / fire;

d) smoke and dust;

e) toxic and asphyxiant gases;

f) chemical attack by corrosive or radioactive gases, aerosols or liquids;

g) shaking of the ground;

h) flooding;

i) lack of water;

j) ground subsidence or collapse and/or landslide;

k) electromagnetic interference - *voltage and frequency variations, immunity to conducted and radiated radio frequency signals, fast voltage transients, surges, voltage dips / drops, short interruptions and flicker, and magnetic fields*;

l) eddy currents into the ground – *can cause heating*.....

ANNEX 4

Reference documents

1) Site Evaluation for Nuclear Installations, IAEA Safety Standards Series No. NS-R-3, International Atomic Energy Agency, Vienna, 2003;

2) External Events Excluding Earthquakes in the Design of Nuclear Power Plants Safety Guide IAEA Safety Standards Series No. NS-G-1.5, International Atomic Energy Agency, Vienna, 2003;

3) Seismic Design and Qualification for Nuclear Power Plants Safety Guide IAEA Safety Standards Series No. NS-G-1.6, International Atomic Energy Agency, Vienna, 2003;

4) Seismic Hazards in Site Evaluation for Nuclear Installations, IAEA Safety Standards Series No. SSG-9, International Atomic Energy Agency, Vienna, 2010;

5) Evaluation of Seismic Hazards for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-3.3, International Atomic Energy Agency, Vienna, 2002;

6) Evaluation of Seismic Safety for Existing Nuclear Installations, IAEA Safety Standards Series No. NS-G-2.13, International Atomic Energy Agency, Vienna, 2009;

7) Meteorological and Hydrological Hazards in Site Evaluation for Nuclear Installations, IAEA Safety Standards Series No. SSG-18, International Atomic Energy Agency, Vienna, 2011;

8) Meteorological Events in Site Evaluation for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-3.4, International Atomic Energy Agency, Vienna, 2003;

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