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# Guidance Document

# Issue T:

# Natural Hazards

## Guidance on Extreme Weather Conditions

Annex to the Guidance Head Document on Natural Hazards

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# 00
# Introduction

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One of the key recommendations from ENSREG following the completion of the European Stress Tests in the aftermath of the TEPCO Fukushima Dai-Ichi accident was to develop reference levels and guidance on the subject of natural hazards to drive harmonisation and improve safety. This recommendation resulted in new WENRA Reference Levels (RLs) specific to Natural Hazards (Issue T), and a corresponding Guidance Head Document that contributes to a consistent interpretation of the RLs and provides insight into the considerations that led to their formulation.

The purpose of this Guidance Document on Extreme Weather Conditions is to provide additional explanations specific to extreme weather hazards. The document forms an Annexe to the Guidance Head Document for the RLs of Issue T and should be read in conjunction with this Guidance Head Document. It is further recommended that the chapters on design extension conditions are read in combination with the Reference Levels of issue F and the Guidance Document of Issue F. Precipitation is also addressed in the Guidance Document on external flooding.

This Guidance Document does not define any requirements in addition to those defined in the RLs of Issue T.

# 01
# Objective

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**T1.1 Natural hazards shall be considered an integral part of the safety demonstration of the plant (including spent fuel storage). Threats from natural hazards shall be removed or minimised as far as reasonably practicable for all operational plant states. The safety demonstration in relation to natural hazards shall include assessments of the design basis and design extension conditions[77] with the aim to identify needs and opportunities for improvement.**

[77] Design extension conditions could result from natural events exceeding the design basis events or from events leading to conditions not included in the design basis accidents.

No guidance needed in addition to the guidance provided for Reference Level T1.1 in the Guidance Head Document.

# 02
# Identification of Natural Hazards
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**T2.1 All natural hazards that might affect the site shall be identified, including any related hazards (e.g. earthquake and tsunami). Justification shall be provided that the compiled list of natural hazards is complete and relevant to the site.**

The identification of extreme weather hazards that might affect the plant under consideration should include the following steps:

- All meteorological and climatological hazards of the region around the site should be identified and their effects should be evaluated.
- Phenomena and credible combinations of phenomena potentially resulting from extreme weather hazards should be determined.
- Also, those hazards should be identified that may not directly impact the plant but could lead to failure of important infrastructure in the vicinity of the site.
- Special consideration should be given to causal dependencies between various external hazards, including hazards other than extreme weather conditions. Examples for such dependencies are forest fires induced by drought or biological hazards triggered by extreme weather conditions (e.g. high water temperatures might be favourable for the growth of algae).

To support the generation of a comprehensive list of hazards, examples of extreme weather conditions are given in Appendix 1 of the Guidance Head Document, including a generic non-exhaustive list of other natural external hazards, which can serve as the starting point for further evaluation.

The list of hazards generated should serve several purposes:

- identification of potential links between hazards with respect to the underlying natural phenomena (e.g. causal links) or with respect to similar impacts on the plant (potential for the implementation of measures providing protection against both hazards);
- revision of natural hazards as part of safety review processes, in response to changes in extreme weather conditions e.g. climate change or due to operating experience feedback.

**T2.2 Natural hazards shall include:**

- **Geological hazards;**
- **Seismotectonic hazards;**
- **Meteorological hazards;**
- **Hydrological hazards;**
- **Biological phenomena;**
- **Forest fire.**

Appendix 1 to the Guidance Head Document contains a non-exhaustive compendium of meteorological events.

# 03
# Site specific natural hazard screening and assessment

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**T3.1** **Natural hazards identified as potentially affecting the site can be screened out on the basis of being incapable of posing a physical threat or being extremely unlikely with a high degree of confidence. Care shall be taken not to exclude hazards which in combination with other hazards[78] have the potential to pose a threat to the facility. The screening process shall be based on conservative assumptions. The arguments in support of the screening process shall be justified.**

[78] This could include other natural hazards, internal hazards or human induced hazards. Consequential hazards and causally linked hazards shall be considered, as well as random combinations of relatively frequent hazards.

For extreme weather conditions, exclusion of hazards due to their lack of physical capability to cause adverse effects should be favoured over an exclusion based on being extremely unlikely with a high degree of confidence, since the restriction of local meteorological data such as wind speed, extreme temperatures, precipitation etc. to a few decades only and the effects of climate change lead to significant uncertainties in the hazard assessments. It should be noted that available meteorological data is in general not as extensive as for earthquake or flooding.

In particular, the occurrence of meteorological hazards such as rain, wind (including tornadoes), snow, hail, lightning, and extreme temperatures (including freezing) should not be screened out for any site.

Special care should be taken not to screen out hazards which are at present negligible but may become relevant in the future due to non-stationarity, e.g. climate change. Also, possible combinations of weather conditions that do not pose a threat on their own should be considered before screening out hazards.

**T3.2 For all natural hazards that have not been screened out, hazard assessments shall be performed using deterministic and, as far as practicable, probabilistic methods taking into account the current state of science and technology. This shall take into account all available data, and produce a relationship between the hazards severity (e.g. magnitude and duration) and exceedance frequency, where practicable. The maximum credible hazard severity shall be determined where this is practicable.**

IAEA SSG-18 [1] provides a description of the general procedure for assessing the hazard associated with extreme values of meteorological parameters or the occurrence of rare hazardous phenomena.

Appropriate methods should be adopted for establishing the hazards that are associated with weather phenomena. The assessment methods should 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 methods. It should be noted that hazard curves are generally needed to conduct probabilistic assessments for external events.

Relevant measured data for weather events is predominantly available for approximately 100 years only. Nevertheless to achieve a relationship between severity and frequency, appropriate statistical models should be used as far as possible for the extrapolation up to $10^{-4}$/y (target value for the design basis events) and beyond (for DEC analysis). Relevant other sources of information to the extent available and applicable such as historical data (including anecdotal 'evidence') and especially representative long term climatic data should be used to support such extrapolations.

For the assessment of the following hazards and phenomena IAEA SSG-18 [1] provides some guidance:

- Air temperature
- Wind speed
- Precipitation
- Snow pack
- Lightning
- Tornadoes
- Waterspouts
- Dust storm and sandstorms
- Hail
- Freezing precipitation and frost related phenomena

In addition, IAEA SSG-3 [2] and IAEA NS-R-3 [3] should be taken into account for high winds and tornadoes.

In particular for precipitation, winds and temperatures the associated time scales should be specified (e. g. maximum amount of precipitation accumulated over various periods of time, typically ranging from 5 min to 24 h or more, characteristic wind speed averaged over 10 minutes, peak temperature, or highest temperature sustained for at least 24 hours.). Estimates of the duration for which the air temperature remains above or below given values (i.e. the persistence) may also be necessary for purposes of plant design.

For each meteorological hazard the phenomena and parameters involved should be investigated and the associated loads should be quantified. For this assessment the usage of complementary approaches (i.e. deterministic and probabilistic) should be considered to determine the site specific hazard severity.

Credible combinations of hazards and phenomena should be considered for the hazard assessment. Examples of correlated events are:

- Drought could be combined with very high temperature events that increase the need for the provision of cooling and at the same time cooling water reservoirs might be reduced.
- Drought (due to high air temperature) could be combined with strong wind and smoke from forest fire.
- With a combination of snow and wind, there is a potential for a loss of offsite power and a simultaneous failure of diesel generators due to air intake blockage, and the possibility of formation of snow banks.
- High winds, high seawater levels and debris in cooling water are correlated, so that there is a possibility of a simultaneous loss of off-site power and a loss of emergency diesel generator cooling.

IAEA SSG-3 [2] provides guidance on dependencies and gives further examples.

Biological hazards (compare Appendix 1 in the Head Guidance Document) can be triggered by extreme weather conditions (e.g. high water temperatures might be favourable for the growth of algae).

Analysis of the environmental conditions should be the starting point for the evaluation of such hazards.

**T3.3 The following shall apply to hazard assessments:**

- **The hazard assessment shall be based on all relevant site and regional data. Particular attention shall be given to extending the data available to include events beyond recorded and historical data.**
- **Special consideration shall be given to hazards whose severity changes during the expected lifetime of the plant.**
- **The methods and assumptions used shall be justified. Uncertainties affecting the results of the hazard assessments shall be evaluated.**

Several kinds of data and associated data sources such as off-site sources of data and information from on-site observation programs should be used to determine the site specific hazard severity. IAEA SSG-18 [1] provides an extensive overview of all data that should be considered. The following generic issues, specific to extreme weather hazards, should be taken into account:

- In the determination of hazards, site specific data (i.e. from the region of interest) should be used. In cases where the site-specific data is sparse or covers only very short observation times, data from other regions that are sufficiently relevant (i.e. similar climatic and topographic conditions) to the region of interest may be used in the determination of hazards. Appropriate and acceptable simulation techniques may also be used. Data obtained for similar regions or by simulation techniques may also be used to augment the available site specific data.

- Relevant meteorological parameters should be continuously measured on-site. The on-site measurements should be used as an additional input for the re-evaluation of the site-specific hazard. Depending on the site-specific conditions it might be necessary to measure the parameters in different locations to get representative data. Monitored meteorological parameters should at least include air temperature, wind speed and wind direction, precipitation and humidity, measured at standard heights.

The size of the region considered in the hazard assessment should be large enough to include all features and areas that could be relevant in the characterization of the meteorological event and the associated natural phenomena.

As events characterized as rarely occurring hazardous meteorological phenomena are unlikely to be recorded at any single location or by a standard instrumented network owing to their low frequency of occurrence and because such events could damage standard instruments or cause unreliable measurements, data from meteorological stations should be supplemented by results obtained from regional meteorological (climate) models to allow or to confirm the specification of extreme meteorological conditions.

The potential for trends or changes in the statistical properties of the phenomena studied should be assessed. Several causes of such non-stationary behaviour can be considered, e.g.:

- Climate change may for instance affect the frequency and intensity of severe weather;
- Physical geography changes such as deforestation which may lead to higher wind speeds and sandstorms.

Other reasons for changes may exist and some may be difficult to estimate or foresee. Such changes should at least be considered in periodic safety reviews (PSR), as requested in section 7.

Assessment of uncertainty for the weather hazards should be done based on the current state of science and technology. Generally accepted solutions may not exist for several assumptions and input parameters. In accounting for aleatory and epistemic uncertainty, alternative models and inputs should be compared in order to support the assessment.

# 04
# Definition of Design Basis Events

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**T4.1 Design basis events[79] shall be defined based on the site specific hazard assessment.**

[79] These design basis events are individual natural hazards or combinations of hazards (causally or non-causally linked). The design basis may either be the original design basis of the plant (when it was commissioned) or a reviewed design basis for example following a PSR.

No additional guidance needed.

**T4.2 The exceedance frequencies of design basis events shall be low enough to ensure a high degree of protection with respect to natural hazards. A common target value of frequency, not higher than $10^{-4}$ per annum, shall be used for each design basis event. Where it is not possible to calculate these probabilities with an acceptable degree of certainty, an event shall be chosen and justified to reach an equivalent level of safety. For the specific case of seismic loading, as a minimum, a horizontal peak ground acceleration value of 0.1 g (where 'g' is the acceleration due to gravity) shall be applied, even if its exceedance frequency would be below the common target value.**

In defining the design basis events for extreme weather conditions, special consideration should be given to the fact that several different weather phenomena may be causally linked due to a common root cause. If the simultaneously occurring loads (e.g. wind and precipitation) from a specific weather event (e.g. a winter-storm) with an exceedance frequency of $10^{-4}$/a cannot be determined, hazard curves for the individual loads should be determined where possible and appropriate loads should be combined to give an equivalent level of safety.

If the site specific hazard assessment for a DBE with a frequency not higher than $10^{-4}$ per annum leads to loads that are lower than those required according to recognized standards (e.g. Eurocode 1 (EC1)), as a minimum design basis event for meteorological hazards the requirements according to the recognized standards (e.g. Eurocode 1 (EC 1)) should be applied. There are dedicated Eurocode standards for snow loads (EN 1991-1-3:2003 [4]), wind loads (EN 1991-1-4:2005 [5]), and thermal loads (EN 1991-1-5:2003 [6]).

**T4.3 The design basis events shall be compared to relevant historical data to verify that historical extreme events are enveloped by the design basis with a sufficient margin.**

No guidance needed.

**T4.4 Design basis parameters shall be defined for each design basis event taking due consideration of the results of the hazard assessments. The design basis parameter values shall be developed on a conservative basis.**

The design basis parameters for each of the meteorological hazards listed in IAEA NS-R-3 [3] and IAEA SSG-18 [1], §6.1 and 6.3 are incorporated by reference.

A particular 'event' is generally characterized by a physical magnitude that defines its severity (velocity, temperature, height etc.) and, where appropriate, a frequency of exceedance of that severity and duration

Besides the severity, the duration of an event might be an important aspect of the design basis event. Therefore, it might be necessary to define more than one design basis event for a given type of hazard. For example, assessing extreme temperatures, two design basis events implying different load scenarios might be identified: one with a maximum temperature over a very limited time period (e.g. 4 hours) and one with a lower (but still high) temperature sustained for more than 24 hours.

To account for future climate change, the design basis events should be chosen in such a way that they cover the projected increase of loads over at least the time span up to the next periodic safety review. For this purpose climate projections according to the state of science and technology should be considered (e.g. such as the projections given in IPCC Reports).

In the analysis of the design basis events, secondary effects should be included systematically, such as secondary missiles, falling objects, failures of high energy pipes, internal flooding, or fires.

As wind loads are considered a major meteorological hazard involving various aspects that require particular attention, the following examples provide information on the derivation of the design basis for wind loading. For other hazards, a comparable approach to specify the DBE should be applied.

### Extreme Winds

For the analysis of extreme winds NS-G-1.5 [7] provides a general description and loadings. In particular, the following aspects should be considered when defining the design basis:

- Wind speed [averaged over specified times],
- Gustiness [roughness of the wind and peak wind speed],
- Suction effects [due to pressure differentials and rate of change of pressure],
- Total duration of the impact,
- Interaction of neighbouring structures [group effects].

### Tornado

The potential for the occurrence of tornadoes in the region of interest should be assessed on the basis of observational and as far as available also instrumentally recorded data for the region as well as on theoretical meteorological considerations.

The hazards associated with tornadoes should be derived and expressed in terms of parameters such as:

- Rotational wind speed,
- Translational wind speed,
- Duration of the wind intensity above specified levels,
- Radius of maximum rotational wind speed,

- Pressure differentials and rate of change of pressure.

In the assessment of the hazard, missiles that could be associated with extreme winds and tornadoes should be considered.

# 05
# Protection Against Design Basis Events

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**T5.1 Protection shall be provided for design basis events.[80] A protection concept[81] shall be established to provide a basis for the design of suitable protection measures**

[80] If the hazard levels of RL T4.2 for seismic hazards were not used for the initial design basis of the plant and if it is not reasonably practicable to ensure a level of protection equivalent to a reviewed design basis, methods such as those mentioned in IAEA NS-G-2.13 may be used. This shall quantify the seismic capacity of the plant, according to its actual condition, and demonstrate the plant is protected against the seismic hazard established in RL T4.2.

[81] A protection concept, as meant here, describes the overall strategy followed to cope with natural hazards. It shall encompass the protection against design basis events, events exceeding the design basis and the links into EOPs and SAMGs.

In order to establish a protection concept, the SSCs that have to be protected should be defined for design basis events (T5) and events more severe than the design basis events (T6). These SSCs are called 'SSCs required by the protection concept' in this guidance[1].

When defining the protection concept for each extreme weather conditions, care should also be taken to ensure the global effectiveness of the various protection concepts.

The protection against extreme weather conditions might be covered by the protection needed for other external hazards (in particular human-made hazards) such as missile impacts (e. g. accidental aircraft crash), explosions and external fires. If, for the protection against extreme weather events the protection against other external events is credited, special consideration should be given to compare all parameters which describe the event under consideration (e.g. in difference to an explosion pressure wave, a tornado generates loadings of underpressure).

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[1] Some but not all SSCs important to safety may be necessary to fulfill the fundamental safety functions depending on the hazards postulated. For a specific hazard:

- Some SCCs important to safety are needed to perform their safety function,
- Some SCCs important to safety may be needed to protect the aforementioned, and
- Some SSCs important to safety do not play a role in coping with the hazard.

For example, it is likely that emergency power generators will be needed to cope with some hazards affecting the plant. These generators will have to be protected against extreme weather hazards. In addition, they will need to be located in a building resistant to extreme weather hazards. Therefore both the emergency power generators and the building will be required by the protection concept.

Another example is the containment (reactor building) which is both necessary for the confinement function and protecting equipment located in the containment. Both of these functions are required by the protection concept.

### Effects of extreme weather hazards on the plant

As part of the protection concept, for each hazard the effects on the plant should be determined. These effects include (but are not limited to):

- Potential precipitation ingress in the rooms housing SSCs important to safety, submersion of equipment,
- Indirect or direct damage of SSCs important to safety by wind, snow, humidity, electrical, mechanical, chemical or biological loads due to extreme weather events,
- Impairment of personnel action (inspections, maintenance, repair…),
- Malfunction of I&C equipment (e.g. due to extreme temperatures or electrical loads),
- Corrosion (e. g. due to salt water),
- Extreme temperatures can affect the usability of diesel fuel or other operational supplies stored at the site, if no technical provisions are in place (warming, insulation, winter-diesel etc.),
- Impact of meteorological phenomena on support functions, such as external electrical supplies, water intake, telecommunications etc.,
- Influence of temperatures on battery power,
- Effects of phenomena correlated with meteorological hazards (such as flooding, fire).

The qualification program for items required by the protection concept should replicate the conditions imposed by extreme weather conditions. The protection concept should take account of the current condition and likely future condition of SSCs.

### Protection measures

Several design provisions could be considered for the protection against extreme weather conditions, for example:

- Intake or water storage structures for the essential service water system should be designed to provide an adequate flow of cooling water during seasonal water level fluctuations, as well as under drought conditions and biological impacts.
- Pipework systems which are important to safety should be protected against extremes of temperature through lagging, trace heating etc..
- Protection of electric systems and I&C against lightning.

Measures should be established to ensure that the SSCs which are required to discharge heat to the UHS still retain their capability under extreme meteorological conditions, particularly if there are long periods when the facilities are not used. These measures should include, for example, monitoring of spray nozzles (freezing) or intake screens (blockage). The effectiveness of these measures should be demonstrated by periodic tests and/or analysis.

Good practice for the protection of SSCs required by the protection concept in case of extreme weather events is to implement several lines of defence, which are independent as far as practicable, with priority given to permanent measures.

It is likely that several independent design provisions are required to provide protection against the entire spectrum of phenomena involved with a given extreme weather event.

The facility should preferably be designed and operated in such a way that extreme weather conditions do not limit the safety functionality of SSCs required by the protection concept.

Particular attention should be paid during design and operation:

- to all openings (shafts, pipes, ducts, stacks etc.) likely to allow rain, snow, hail, wind- and sandstorms etc. to enter into buildings housing SSCs required by the protection concept;
- to the possibility of bypasses of on-site protective measures (rail tracks, exhaust lines, etc.).

If potential ingress paths for rain, snow, hail etc. into rooms housing SSCs required by the protection concept are identified, passive protective measures should be provided as far as reasonably practicable, so that operator action necessary to plug or close these ingress paths during extreme weather conditions are minimized.

In determining whether heavy rainfalls are relevant for the static design of flat roofs, the possibility of drainage blockage due to foliage etc. should be considered.

If rainwater drainage systems can have an impact on safety, they should be classified according to their importance to safety and should be considered accordingly in inspection programs to regularly verify their actual status and check their operability after plant modifications. In this case, they should be designed robust, e.g. with respect to loads due to blockages.

**T5.2 The protection concept shall be of sufficient reliability that the fundamental safety functions are conservatively ensured for any direct and credible indirect effects of the design basis event.**

No guidance needed in addition to the guidance provided for RL T5.2 in the Guidance Head Document.

**T5.3 The protection concept shall:**

**a) apply reasonable conservatism providing safety margins in the design;**

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

**c) ensure that measures to cope with a design basis accident remain effective during and following a design basis event;**

**d) take into account the predictability and development of the event over time;**

**e) ensure that procedures and means are available to verify the plant condition during and following design basis events;**

**f) consider that events could simultaneously challenge several redundant or diverse trains of a safety system, multiple SSCs 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).**

### Administrative measures

The choice and design of measures requiring human intervention should take into account the possibility of anticipating the natural events and their development over time.

Note that early warning systems should complement rather than replace protection measures.

Administrative measures should be considered. Depending on the site, these measures could be based on information provided by technical measures such as:

- Monitoring systems;
- Detection system at the site;
- Detection systems in buildings/rooms housing systems or components important to safety;
- Early warning systems.

### Multi-units sites

Where there is more than one facility at the site, account should be taken in the safety assessment of the effect of a single external event, such as extreme temperature, on all of the facilities and activities, and of the potential hazards presented by each facility or activity to the others. This should be taken into account in designing the protection measures and in allocating on-site and off-site accident management provisions.

If fulfilment of safety functions during extreme weather events requires the use of equipment, common services or human resources shared by several installations, the ability of this equipment to fulfil the safety functions under these conditions should be justified, considering that all facilities at the site may be affected at the same time.

### Examples of hazard specific protection measures in the case of lightning

Lightning protection should be installed in order to ensure that SSCs required by the protection concept are not unduly affected by the effects of lightning. Recognised standards should be used to ensure that the required level of safety according to T4.2 is achieved.

The lightning protection measures and the electrical equipment should be designed and coordinated with each other such that the influence of lightning strikes on electrical facilities will not lead to unacceptable effects on plant safety (e.g. inhibition or spurious activation of protective actions, lightning induced fires or failure of components required by the protection concept).

**T5.4 For design basis events, SSCs identified as part of the protection concept with respect to natural hazards shall be considered as important to safety.**

No guidance needed in addition to the guidance provided for RL T5.4 in the Guidance Head Document.

**T5.5 Monitoring and alert processes shall be available to support the protection concept. Where appropriate, thresholds (intervention values) shall be defined to facilitate the timely initiation of protection measures. In addition, thresholds shall be identified to allow the execution of pre-planned post-event actions (e.g. inspections).**

No guidance needed in addition to the guidance provided for RL T5.5 in the Guidance Head Document.

**T5.6 During long-lasting natural events, arrangements for the replacement of personnel and supplies shall be available.**

### Access to the plant

The risk of "plant isolation" due to extreme weather conditions (e.g. heavy snowfall) should be analysed. If the access to the plant is impeded, the feasibility of the necessary on-site actions should be guaranteed. The protection concept should include the implementation of necessary operating procedures, the availability of the required personnel and equipment, and communication necessary for the management of the event.

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# 06
# Considerations for Events More Severe than the Design Basis Events

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**T6.1** **Events that are more severe than the design basis events shall be identified as part of DEC analysis. Their selection shall be justified.[82] Further detailed analysis of an event will not be necessary, if it is shown that its occurrence can be considered with a high degree of confidence to be extremely unlikely.**

[82] see issue F section 2

For meteorological hazards the site specific data and the available hazard assessment methods typically do not allow for a meaningful extrapolation to events with exceedance probabilities lower than $10^{-4}$/a. In some cases, it is possible to compensate for this by using data from comparable regions in addition to those of the region of the site itself.

**T6.2** **To support identification of events and assessment of their effects, the hazards severity as a function of exceedance frequency or other parameters related to the event shall be developed, when practicable.**

No guidance needed in addition to the guidance provided for RL T6.2 in the Guidance Head Document.

**T6.3** **When assessing the effects of natural hazards included in the DEC analysis, and identifying reasonably practicable improvements related to such events, analysis shall, as far as practicable, include:**

- **a) demonstration of sufficient margins to avoid "cliff-edge effects" that would result in loss of a fundamental safety function;**
- **b) identification and assessment of the most resilient means for ensuring the fundamental safety functions;**
- **c) consideration that events could simultaneously challenge several redundant or diverse trains of a safety system, multiple SSCs or several units at multi-unit sites, site and regional infrastructure, external supplies and other countermeasures;**
- **d) demonstration that sufficient resources remain available at multi-unit sites considering the use of common equipment or services;**
- **e) on-site verification (typically by walk-down methods).**

(T6.3 a) The effects of a step-wise increase of the design basis parameters (such as static or dynamic pressure, minimum or maximum temperature, additional loads) may be assessed for each relevant SSC. Realistic assumptions and best estimate methods can be used. If, for a certain SSC its availability can no longer be assured when a threshold value is exceeded, then that value defines the margin relative to the design basis.

If the available data allows the determination of exceedance probabilities for weather events exceeding the design basis, the margins in terms of capacity determined by the above mentioned approach can be converted into margins in terms of exceedance probability. If the data available does not allow (and cannot be extended to allow) for such an assessment, the ultimate capacity of the plant (capacity of the weakest SSC in the most robust success path) may be compared to the severity and the associated loads of historical extreme natural events (in the region of the site, in comparable regions, and worldwide) and - wherever applicable - physical limits. This comparison would help to assess the approximate extent of the available margin.

If the capacity of SSCs due to the design against other loads (not only from external events) is credited in the evaluation of safety margins with respect to meteorological hazards, it should be verified that the boundary conditions for both situations are comparable (i. e. that the load combination due to the covering event envelopes the load combinations due to the meteorological hazard under consideration).

(T6.3 b, c) For a meteorological event that is more severe than the design basis event, the assessment of the impact of the external hazard on the protection measures can be focused on (but should not necessarily be limited to) the most resilient means for ensuring the fundamental safety functions. In the analysis of droughts for example, an assessment of the availability of river water (as UHS) might be omitted if there is a source of underground water that serves as UHS for the essential service water system which can be shown to be available in the considered scenario.

According to the head guidance document, an assessment of the length of the period over which the safe (shutdown) state can be maintained in case of site isolation should be performed. For such an assessment, only SSCs and mobile equipment can be credited that are available under the conditions of the natural event more severe than the design basis event that caused the site isolation.

# 07
# Reviews of the Site Specific Natural Hazards

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Issue P requires periodic safety reviews. This guidance provides further, specific guidance for the treatment of extreme weather conditions in such reviews.

The meteorological conditions of relevance to the nuclear installation should be monitored over the lifetime of the nuclear installation. Particular attention should be paid to the identification of potential effects of non-stationarities such as climate change. If such non-stationarities are identified, the respective design basis events should be revised.

An example could be changes in environmental conditions (average annual wind speed and maximum annual wind speed, water level, temperature, local precipitation, etc.) leading to an increase in the frequency of natural hazards with higher damage potential.

Further causes for a review of hazards and design basis parameters could be new insights from probabilistic safety analyses, from the analysis of operational experience of NPPs worldwide and industrial facilities close to the site, or from new findings in meteorological or climate sciences. Given the pace of change in modelling capability and underpinning scientific knowledge with respect to extreme weather events, specific reviews might be prudent in between regular periodic safety reviews.

The review of the site specific extreme weather hazards should include:

- the evaluation of new knowledge on the extreme weather hazards, due to new data or new assessment methods and models;
- the evaluation of recent experience from weather events, particularly those with impact to nuclear power plants worldwide and those close to the site;
- the condition assessment of the SSCs with particular focus on their compatibility with the design requirements.

# References


[1] IAEA, 2011. Meteorological and Hydrological Hazards in Site Evaluation for Nuclear Installations. Specific Safety Guide No. SSG-18, Vienna.

[2] IAEA, 2010. Development and Application of Level 1 Probabilistic Safety Assessment for Nuclear Power Plants. Safety Guide No. SSG-3, Vienna.

[3] IAEA, 2003. Site Evaluation for Nuclear Installations. Safety Requirements No. NS-R-3, Vienna.

[4] CEN, 2009. Eurocode 1: Actions on structures – Part 1-3: General actions - Snow loads. EN 1991-1-3:2003 + AC:2009, Brussels.

[5] CEN, 2010. Eurocode 1: Actions on structures – Part 1-4: General actions – Wind actions. EN 1991-1-4:2005 + A1:2010 + AC:2010, Brussels.

[6] CEN, 2009. Eurocode 1: Actions on structures – Part 1-5: General actions – Thermal actions. EN 1991-1-5:2003 + AC:2009, Brussels.

[7] IAEA, 2003. External Events Excluding Earthquakes in the Design of Nuclear Power Plants. Safety Guide No. NS-G-1.5, Vienna.