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UK ABWR Generic Design Assessment

Generic PCSR Chapter 6 : External Hazards

Hitachi-GE Nuclear Energy, Ltd.

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6.1 Introduction

External hazards are natural hazards and man-made hazards, which include earthquake, aircraft impact, extreme weather, electromagnetic interference, flooding and etc. This document defines the external hazards that are considered in UK ABWR design, except for terrorism and malicious acts, which is treated separately and explicitly in UK ABWR design.

6.2 Interface with other Documents

This chapter contains information about external hazards protection. The structure of the document for external hazard protection is shown in Fig. 6.2-1. Scopes of each document are shown below:

1) PCSR Chapter 6 "*External Hazards*" - this chapter -
This chapter presents the identification of external hazards considered in UK ABWR design. Combinations of external hazards are also considered. High level safety claims are described. The definitions of the hazard, protection policy and UK generic condition are defined for each hazard.

2) PCSR Chapter 2 "*Generic Site Envelope*"
The relevant parameters defined within this report will be enveloped into a set of Generic Site Conditions that can be used for candidate UK sites. Standard UK ABWR Structures, Systems and Components (SSCs) shall be designed to accommodate the Generic Site Conditions.

3) PCSR Chapter 25 "*Probabilistic Safety Assessment*"
This chapter describes UK ABWR Probabilistic Safety Assessment (PSA) to assess the plant risk, to identify potential plant vulnerabilities and to quantify the public risk. Confirmation to SAP risk targets is demonstrated.

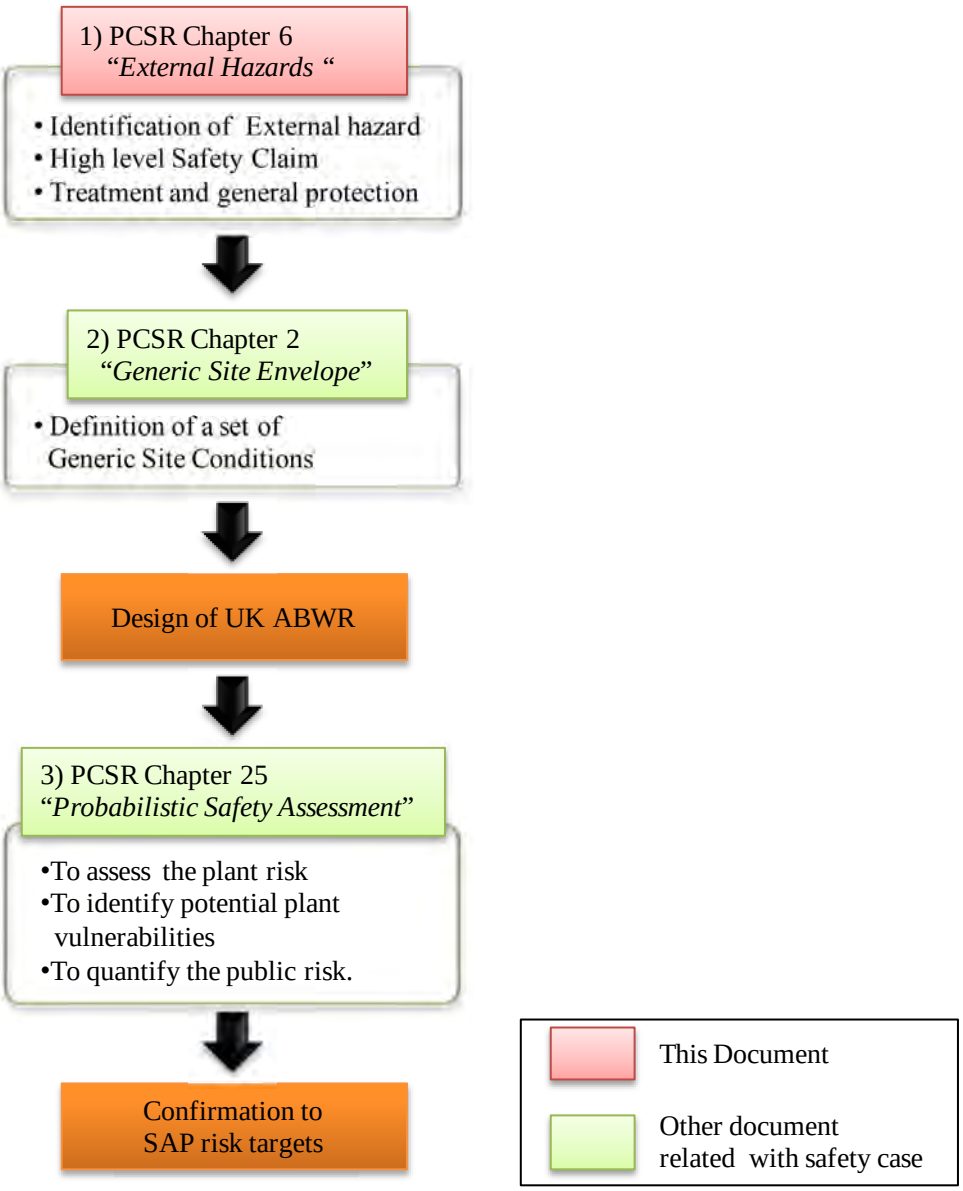

Figure 6.2-1: Safety Case Document Structure for External Hazard Assessment

6.3 Scope of this Chapter

A comprehensive external hazard list has been developed, taking into account all external hazards. The comprehensive list has been reviewed and categorised such that Hitachi-GE has identified those independent external hazards to be considered in the design of the UK ABWR. Combined external hazards are also considered and for these hazards, the protection policy and UK generic conditions are defined.

6.4 Identification of Independent External Hazard for GDA

The process for identifying independent external hazard consists of following five steps:

1. Hazard Identifcation
2. Grouping by Denomination
3. Grouping by Plant Effect
4. Hazard Screening
5. Hazard Classification

The hazard identification process is unified up to the step 5 (Hazard Classification), for both GDA and SLA work. Beyond this stage, the GDA and SLA hazards are treated separately in the work leading into the PSA.

6.4.1 Listing

The following standard definition from the SAPs will be applied. It states that external hazards are those natural or man-made hazards to a site and facilities that originate outside to both the facilities' site and its processes, where the dutyholder has no control over the initiating event. External hazards are natural hazards as well as man-made hazards, which include earthquake, aircraft impact, extreme weather, electromagnetic interference, flooding and etc.

a) Natural hazards

Natural hazards are those that take place at the site as a result of the geophysical location and prevailing meteorological conditions, e.g. flooding, extreme wind, ground motion.

b) Man-made hazards

Those are the hazards that may affect a plant settled in a particular location, as a result of human's presence or utilisation of an area near or adjacent to the site, e.g. external explosions, fires, or aircraft impacts.

The comprehensive list of external hazards, that helps to underpin this PCSR chapter, was compiled and documented in the report for the Derivation and Justification of the External Hazards [Ref-2]. Table 6.4-1 of this PCSR chapter lists the reference sources used to inform the production of the report [Ref-2].

Table 6.4-1: Reference Source for Comprehensive List of External Hazard

Note: this table is an extract from the References given in [Ref-2]

No.	Reference Source
1	USNRC, "PRA Procedures Guide" (NUREG-CR-2300)
2	Pre-Construction Safety Report (Sizewell B PCSR)
3	OECD Nuclear Energy Agency (NEA), "Probabilistic Safety Analysis (PSA) of the Other External Events Than Earthquake, "
4	WENRA RHWG, "Report Safety of new NPP designs - Study by Reactor Harmonization Working Group RHWG", March 2013.
5	USNRC, "PRA Procedural and Submittal Guidance for the Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities," & "Evaluation of External Hazards to Nuclear Power Plants in the United States," (NUREG 1407&NUREG/CR-5042)
6	IAEA, "External Events Excluding Earthquakes in the Design of Nuclear Power Plants" (IAEA Safety Guide, NS-G-1.5)
7	European Utilities Requirements (EUR), Volume 2, Section 2.4, "Generic Nuclear Island Requirements: Design Basis,"
8	Swedish Nuclear Inspectorate (SKI), "Guidance for External Events Analysis"
9	HSE, "Technical Assessment Guide" 013
10	HSE, "Generic Design Assessment Guidance to Requesting Parties" (ONR-GDA-GD-001 Revision 0)
11	NNB Gen Co LTD, "Hinkley Point C PCSR C PCSR Assessment Guidance to Requesting Parties" (ONR-GDA-GD-001 Revision 0), Hazards Protection, A (HPC-NNBOSL-U0-000-RET-000046 Issue 2), 22/08/2012.

6.4.2 Grouping by Denomination

Some hazards may be bounded (in both frequency and consequence) with another hazard or Design Basis faults, then it can be screened-out for further consideration. The event is included in a combined event if it causes risk increase in connection with some other event as noted in the report for the Derivation and Justification of External Hazards [Ref-2].

6.4.3 Grouping by Plant Effect

Hazards are grouped with another hazard based on plant effect. If the hazard's potential impacts are similar, these hazards are grouped to avoid repetition of the same description of definition and protection as noted in the report for the Derivation and Justification of External Hazards [Ref-1].

6.4.4 Screening

Any generic type of hazard with a total frequency that is demonstrably below once in ten million years may be excluded. A cut off frequency of 10^{-7} pa should be applied to remove the hazard purely on the basis of frequency of occurrence as noted in the report for the Derivation and Justification of External Hazards [Ref-1].

6.4.5 Classifying Hazards into GDA

If there is great variability of potential hazard load among candidate UK sites, it is reasonable to consider the protection against the hazard for each site as the basis for ALARP. Hazards are reviewed and classified into GDA and SLA as noted in the report for the Derivation and Justification of External Hazards [Ref-1].

As a result of the hazard identification process above, the following 14 external hazards have been identified for assessment:

- Air Temperature
- Wind
- Rainfall & Ice
- Drought
- Snow
- Electromagnetic Interference (EMI)
- Sea or River Water Temperature
- External Flooding
- Seismic Activity
- Loss of Offsite Power (LOOP)
- Aircraft Impact
- External Fire
- External Missile
- External Explosion

6.5 Identification of Combined External Hazard in GDA

6.5.1 Categorisation of Combined Hazards

Combinations of events when external hazards lead to internal hazards are described in PCSR Chapter 7 "*Internal hazards*". In this section, combinations of external hazards which are extracted as independent hazards in section 6.4 of this PCSR chapter are considered. There are three types of combinations of external hazards as shown below:

Category I Combination of consequence events

In this event, one hazard originates (or causes) the other hazard consecutively, such as fire or flooding following an Seismic Activity event. They should be considered as combined event.

Category II Combination of coincident events

Coincident events are random independent events that happen simultaneously. In this event, more than one hazard is derived same meteorological conditions.

Category III Combination of independent events

In this event, more than one hazard occurs simultaneously or successively within a given period of time including correlated hazards and those combinations which occur randomly.

6.5.2 Category I: Combination of Consequence Events

As a preliminary assessment, the combinations of hazard groups considered in GDA are reviewed and classified into three categories [Ref-1]. Further work will be developed in Step 3.

6.5.3 Category II: Combination of Coincident Events

Metrological events such as heavy rainfall and high air temperature may occur at the same time. However, the combination of extreme severe events whose occurrence probability is 1 in 10,000 years return period is unrealistic assumption. High frequency event with small load may occur simultaneously. When considering defence-in-depth and redundancy and diversity, the combined load of these realistic events is enveloped by individual hazard protection. Therefore, combinations of coincident events do not need to be considered in GDA and SLA [Ref-1]. Further work will be developed in Step 3.

6.5.4 Category III: Combination of Independent Events

Most of combined hazards are classified in this category. In most cases, the duration which is necessary to reach stable condition is within several days. Combined independent events are lower than 10^{-7} pa. Thus, these events should be screened out.

The combinations of higher frequency lower consequence events may occur. When considering defence-in-depth and redundancy and diversity, the combined load of these events is enveloped by individual hazard protection. Therefore, combinations of coincident events do not need to be considered in GDA and SLA [Ref-1]. Further work will be developed in Step 3.

6.6 High Level Safety Claims of UK ABWR for External Hazard

High level safety claims of UK ABWR for external hazard are shown below.

- The safety functions of UK ABWR are maintained against external hazard within nominated UK site.

The safety functions identified with one of the four high-level safety functions, which are similar to the fundamental safety functions:

(1) Control of Reactivity
(2) Fuel Cooling
(3) Long Term Heat Removal
(4) Confinement/Containment of radioactive materials

A list of UK ABWR plant's level safety functions identified from above development is described in PCSR Chapter 5 "*Categorisation and Classification of Structures, Systems and Components (SSCs)*".

6.7 Treatment and General Protection

This section presents the definition of the hazard, protection policy and UK generic site condition for each hazard, for the GDA [Ref-1].

In the following sub-sections, the Hazard Group and its identifier, together with the Hazard Condition and its identifier, are taken from part of Table 4 of the Derivation and Justification of External Hazards report [Ref-2].

6.7.1 Air Temperature

1) Definition of the hazard
Extreme high and low air temperatures pose potential failure of cooling or ventilation plant and brittle fracture of steel structures, respectively. This section describes the characteristics of the extreme air temperature surrounding the nuclear power station. The generic design of the nuclear power station should consider the extreme air temperature conditions of the nominated UK sites. HVAC, civil structures and so on, should be designed based on these air temperatures. HVAC control temperature and humidity to ensure the integrity of SSCs, and provide acceptable working conditions.
This hazard group consists of hazards shown in Table 6.7-1.

Table 6.7-1: Air Temperature Group

Hazard Group Ref. ID #	Hazard Condition	Remarks
A10	Humidity	-
A30	Temperature Extremes (Air)	-
A3	Climate Change	This effect is considered in other hazards.
A20	Extreme Meteorological Conditions	This effect is considered in other hazards.

The data should clearly define the maximum and minimum air temperatures. “Maximum temperature” is defined as the maximum daily air temperature. “Minimum temperature” is defined as the minimum daily air temperature. Relative humidity is the ratio of the amount of atmospheric moisture present relative to the amount that would be present if the air were saturated.

These data should be derived from historical data relating to the nominated site in UK. 10,000 years return periods for maximum and minimum temperatures are considered. The effects of climate change should also be taken into consideration.

2) Protection policy
SSCs that deliver the safety functions are protected from extremely high and low air temperatures by

civil structure. The atmosphere inside buildings is maintained appropriately by HVAC. The design principles for the scope of the civil structures and HVAC in GDA are described in PCSR Chapter 10 "*Civil Works and Structures*" and Chapter 9 "*General Description of the Unit (Facility)*", simultaneously.

3) Evaluation condition

Based on the data of air temperatures and humidity in the nominated site, parameter values for UK ABWR are determined. Evaluation condition is described in PCSR Chapter 2 "*Generic Site Envelope*". In SLA, the candidate site values should be compared with the generic site values.

6.7.2 Wind

1) Definition of the hazard group

This chapter describes the characteristics of the wind surrounding the nuclear power station. The generic design of the nuclear power station should consider the wind conditions of the nominated UK sites. High intensity winds, in particular in the case of tropical storms and tornadoes, may generate missiles such as flying debris and projectiles. Flying Debris generated by tornado is considered as the event consequence of External Missile (section 6.7.13) as Natural Originated Missile.

This hazard group consists of hazards shown in Table 6.7-2.

Table 6.7-2: Wind Group

Hazard Group Ref. ID #	HazardCondition	Remarks
A4	Extreme winds, tornadoes, cyclones, typhoon, hurricane	-
A3	Climate Change	This effect is considered in other hazards.
A20	Extreme Meteorological Conditions	This effect is considered in other hazards.

The wind speed near the surface of the earth varies. And it is greatly affected by the presence of irregularities in the ground or nearby obstacles such as trees or buildings. The standard exposure of wind measuring instruments over open, level terrain is several meters above the ground. The generic UK ABWR plant is designed to accommodate standard wind speed that is defined considering extreme wind condition of the nominated UK sites.

These data should be derived from historical data relating to the nominated site in UK. 10,000 years return periods for wind speed are considered. The effects of climate change should also be taken into consideration.

2) Protection policy

SSCs that deliver the safety functions are protected from wind by civil structure. The atmosphere inside buildings is maintained appropriately. The design principles for the scope of the civil structures in GDA are described in PCSR Chapter 10"*Civil Works and Structures*".

The design principles for the scope of the HVAC and SGTS in GDA are described in PCSR Chapter 16 "*Auxiliary Systems*" and Chapter 13 "*Engineered Safety Features*", respectively.

3) Evaluation condition

Based on the data of the wind speed in the potential site, parameter values for UK ABWR are

determined. Evaluation condition is described in PCSR Chapter 2 "*Generic Site Envelope*". In SLA, the candidate site values should be compared with the generic site values.

6.7.3 Rainfall & Ice

1) Definition of the hazard group

All of civil engineering structures and drainage systems should be considered to drain local intense Rainfall & Ice away from safety related structures, systems and components. This chapter describes the characteristics of the Rainfall & Ice surrounding the nuclear power station. Heavy rainfall may cause the elevation of groundwater level. This event is considered as the event consequence of External flooding (section 6.7.8).

This hazard group consists of hazards shown in Table 6.7-3.

Table 6.7-3: Rainfall & Ice Group

Hazard Group Ref. ID #	Hazard Condition	Remarks
A8	Hail, Sleet, Snow and Icing	-
A14	Ice (Frazil)	-
A15	Ice (Rime)	-
A16	Ice (Barriers)	-
A6	Frost, soil frost	-
A22	Rainfall (extreme) & Intense precipitation	-
A3	Climate Change	This effect is considered in other hazards.
A20	Extreme Meteorological Conditions	This effect is considered in other hazards.

The data will clearly define maximum rainfall rate as the maximum daily rainfall. Rainfall also includes snow, sleet and hails as well as small amounts from dew, hoar frost and rime, melted and measured as rainfall.

These data should be derived from historical data relating to the nominated site in UK. 10,000 years return periods for rainfall rate are considered. The effects of climate change should also be taken into consideration.

2) Protection policy

SSCs that deliver the safety functions are protected from Rainfall & Ice by civil structure. The atmosphere inside buildings is maintained appropriately. The design principles for the scope of the civil structures and drainage systems in GDA are described in PCSR Chapter 10 "*Civil Works and Structures*".

3) Evaluation condition

Based on the data of the Rainfall & Ice in nominated site, parameter values for UK ABWR are

determined. Evaluation condition is described in PCSR Chapter 2"*Generic Site Envelope*". In SLA, the candidate site values should be compared with the generic site values.

6.7.4 Drought

1) Definition of the hazard group

A severe drought may cause drawdown of water level. The drawdown poses the loss of cooling water. This chapter describes the characteristics of the drought surrounding the nuclear power station. This hazard group consists of hazards shown in Table 6.7-4.

Table 6.7-4: Drought Group

Hazard Group Ref. ID #	Hazard Condition	Remarks
C1	Drought	-
A3	Climate Change	This effect is considered in other hazards.
A20	Extreme Meteorological Conditions	This effect is considered in other hazards.

The general protection against the drought depends on water intake destination. For seawater cooling, sea water level is defined considering extreme condition of the nominated UK sites.

These data should be derived from historical data relating to the nominated site in UK. 10,000 years return periods for wind speed are considered. The effects of climate change should also be taken into consideration.

2) Protection policy

The cooling water intake level should be constructed below the sea water level.

3) Evaluation condition

Evaluation condition is described in PCSR Chapter 2"*Generic Site Envelope*". In SLA, the candidate site values should be compared with the generic site values.

6.7.5 Snow

1) Definition of the hazard group

All of civil engineering structures should be considered and designed based on snow load conditions of the potential UK sites. This chapter describes the characteristics of snow load surrounding the nuclear power station.

This hazard group consists of hazards shown in Table 6.7-5.

Table 6.7-5: Snow Group

Hazard Group Ref. ID #	Hazard Condition	Remarks
A39	Snow pack and Snow Melt	-
A44	Extreme Snow	-
A3	Climate Change	This effect is considered in other hazards.
A20	Extreme Meteorological Conditions	This effect is considered in other hazards.

Maximum snow load should be clearly defined. These data should be derived from historical data relating to the nominated site in UK. 10,000 years return periods for rainfall rate are considered. The effects of climate change should also be taken into consideration.

2) Protection policy

SSCs that deliver the safety functions are protected from snow load by civil structure. The design principles for the scope of the civil structures in GDA are described in PCSR Chapter 10"*Civil Works and Structures*".

3) Evaluation condition

Based on the data of snow load in nominated site, parameter values for UK ABWR are determined. Evaluation condition is described in PCSR Chapter 2"*Generic Site Envelope*". In SLA, the candidate site values should be compared with the generic site values.

6.7.6 Electromagnetic Interference (EMI)

1) Definition of the hazard group

This hazard group consists of hazards shown in Table 6.7-6.

Table 6.7-6: EMI Group

Hazard Group Ref. ID #	Hazard Condition	Remarks
A17	Lightning	-
D7	Electromagnetic Interference (EMI)	-

Lightning is an electrical discharge most commonly produced in thunderstorms, usually accompanied by thunder. It occurs in clouds with vigorous convection where enough electrical charge is separated through the movement of cloud droplets and Rainfall & Ice particles. The severity of lightning is defined as the frequency of lightning strikes on the ground.

EMI from the industrial environment and transport routes can cause disturbances that affect electrical systems by interrupting, obstructing or degrading their performance. EMI can originate from both artificial (e.g. communication systems) and naturally occurring sources (e.g. Lightning). Potential sources of EMI have been identified and characterised as either natural or artificial (both intentional and unintentional). These sources are listed below;

- Natural EMI sources - Sources that are associated with natural phenomena. They include atmospheric charge/discharge phenomena such as Lightning and Solar Flares, which is extraterrestrial sources including radiation from the sun.
- Man-made EMI sources - Sources associated with man-made devices such as power lines. Intentional radiating emitters - Emitters whose primary function depends on radiated emitters.

2) Protection policy

The electrical system should be designed to be robust to external hazards. The design principles for the scope of instrumentation and control systems are described in PCSR Chapter 15 "*Electrical Power Supplies*" and Chapter 14"*Control and Instrumentation*", respectively. EMI as an internal hazard are discussed in PCSR Chapter 7"*Internal hazards*".

3) Evaluation condition

Evaluation condition is described in PCSR Chapter 2"*Generic Site Envelope*". In SLA, the candidate site values should be compared with the generic site values.

6.7.7 Sea or River Water Temperature

1) Definition of the hazard group

The UHS (Ultimate Heat Sink) serves the safety functions of providing cooling water and acting as a heat sink for the system during accident conditions. The UHS also serves as a heat sink during normal operation by accepting the heat load of the Reactor Building Cooling Water System (RCW) and Reactor Building Service Water System (RSW).

This hazard group consists of hazards shown in Table 6.7-7.

Table 6.7-7: Sea or River Water Temperature Group

Hazard Group Ref. ID #	Hazard Condition	Remarks
A32	Temperature Extremes (Sea / River)	-
A3	Climate Change	This effect is considered in other hazards.
A20	Extreme Meteorological Conditions	This effect is considered in other hazards.

The minimum and maximum cooling water temperatures of UHS for UK ABWR are determined in consideration of the cooling water temperature of the candidate site condition as well as of the following conditions;

These data should be derived from historical data relating to the nominated site in UK. 10,000 years return periods for maximum and minimum sea water temperatures are considered. The effects of climate change should also be taken into consideration.

2) Protection policy

The UHS is designed to provide an adequate source of cooling water which is available at all times for reactor operation, shutdown cooling and for accident mitigation.

The cooling water systems such as RCW and RSW and the heat removal systems including the Residual Heat Removal System (RHR) are also designed based on this minimum and maximum cooling water temperature from UHS.

3) Evaluation condition

Based on the above condition, parameter values for UK ABWR are determined. Evaluation condition is described in PCSR Chapter 2"*Generic Site Envelope*". In SLA, the candidate site values should be compared with the generic site values.

6.7.8 External Flooding

1) Definition of the hazard group

The safety of nuclear power plants can be seriously affected by flooding. External Flooding pose potential failure of structures, systems and components by the infiltration of water into internal areas of the plant. This section describes the characteristics of design consideration against external flooding.

This hazard group consists of hazards shown in Table 6.7-8.

Table 6.7-8: External Flooding Group

Hazard Group Ref. ID #	Hazard Condition	Remarks
A26	Low / High Sea water level	-
A29	Storm surge	-
B21	Tsunami	-
C3	Groundwater	-
C4	High tide, high lake level, or high river stage	-
C9	Tidal effects (Flooding)	-
C11	Waves	-
A22	Rainfall (extreme) & Intense precipitation	-
C15	Dam Failure	-
D26	Pipeline Accident (Gas, Oil, Water, etc.)	-
A3	Climate Change	This effect is considered in other hazards.
A20	Extreme Meteorological Conditions	This effect is considered in other hazards.

Coastal Flooding is usually a result of a combination of different factors such as sea water levels, storm surge, tides and tsunami, and so on. The highest possible sea water level would be caused by a combination of a high spring tide, a coincident surge and coincident maximum wave height conditions. Storm surges are short-lived local increases in water level above that of the tide and are driven by wind and atmospheric pressure gradients. The maximum flooding level is defined as the highest of mean sea level Above Ordnance Datum (AOD).

These data should be derived from historical data relating to the nominated site in UK. 10,000 years return periods for flooding level are considered. The effects of climate change should also be taken into account.

2) Protection policy

SSCs that deliver the safety functions are protected from external flooding by civil structure. The

atmosphere inside buildings is maintained appropriately. The design principles for the scope of the civil structures in GDA are described in PCSR Chapter 10 "*Civil Works and Structures*".

3) Evaluation condition

Based on the data in the potential site, parameter values for UK ABWR are determined. Evaluation condition is described in PCSR Chapter 2*"Generic Site Envelope"*. In SLA, the candidate site values should be compared with the generic site values. The site license holder should take into account of the effects of external flooding and considered the following:

- The ground level of the site should be constructed above the level of the established external flooding level.
- Coastal sea level protection measures should be constructed around the nuclear power station.
- Watertight doors should be used where applicable for the protection of important SSCs.

6.7.9 Seismic Activity

1) Definition of the hazard group

This hazard group consists of hazards shown in Table 6.7-9.

Table 6.7-9: Seismic Activity Group

Hazard Group Ref. ID #	Hazard Condition	Remarks
B16	Seismic Activity (Earthquake)	-
B4	Dynamic Compaction (Earthquakes)	-
B7	Faults	-
B36	Minimum Shear Wave Velocity	-
B37	Minimum Static Bearing Capacity	-
B15	Liquefaction (Earthquake)	-

The spectrum used for the DBE (Design Basis Earthquake) for the generic site is required to envelope that for the nominated site. Candidate sites in UK are classified as hard sites. Besides, the EUR (see table 6-1, No.7) hard site spectrum envelopes a UHS of 10^{-4} annual probability of exceedance earthquake required for Seismic Categories 1 and 1A for the candidate site. Therefore, the earthquake derived from the EUR hard site spectrum is applicable to the DBE. In addition, two orthogonal horizontal components and a vertical component are considered for the DBE.

Average allowable static bearing capacity and maximum allowable dynamic bearing capacity demand are determined, including a factor of safety, based on the averaged bearing pressure of the footprint of the structure and the maximum bearing reaction derived from 3D analysis results under the all necessary load combinations, respectively.

2) Protection policy

See PCSR Chapter 2 *"Generic Site Envelope"*.

3) Evaluation condition

See PCSR Chapter 2 *"Generic Site Envelope"*.

6.7.10 Loss of Offsite Power

1) Definition of the hazard group

Meteorological and hydrological phenomena may simultaneously affect all the structures, systems and components important to safety on a nuclear installation site. This could lead to the risk of common cause failure for systems important to safety, such as the emergency power supply systems, with the associated possibility of Loss of Off-site Power (LOOP). This chapter describes the characteristics of the design consideration against LOOP. The design of the nuclear power station considers LOOP.

This hazard group consists of hazards shown in Table 6.7-10.

Table 6.7-10: LOOP Group

Hazard Group Ref. ID #	HazardCondition	Remarks
D19	LOOP	-

LOOP as an internal initiating event is characterised by its frequency and duration.

2) Protection policy

The electrical system should be designed to be robust to external hazards. Main protection against a Loss of Off-site Power will be the introduction of Alternating Current (AC) power supply via Emergency Diesel Generators (EDGs). The design principles for the scope of the electrical power supply system GDA are described in PCSR Chapter 15"*Electrical Power Supplies*".

3) Evaluation condition

Evaluation condition is described in PCSR Chapter 2*"Generic Site Envelope"*. In SLA, the candidate site values should be compared with the generic site values.

6.7.11 Aircraft Impact

1) Definition of the hazard group

Intentional aircraft impact is assessed as a Beyond Design Basis (BDB) event in the GDA process by deterministic approach. On the other hand, whether an accidental aircraft impact is assessed or not depends on the accidental crash frequency. In this section, accidental aircraft impact is treated.
This hazard group consists of hazards shown in Table 6.7-11.

Table 6.7-11: Aircraft Impact Group

Hazard Group Ref. ID #	Hazard Condition	Remarks
D1	Aircraft Impact (Accidental)	-

2) Protection policy

The objective of this protection is to prevent core melt and therefore not to cause more than a minor radiological impact [Ref-3]. Safety functions required to bring and maintain the plant in a safe state after such a crash are designed and protected adequately.
In particular, the following are ensured:

- Reactivity control, including reactor scram
- Residual heat removal (including in the long term) from the core in the vessel and the fuel pool in order to exclude core or fuel melt
- Confinement of radioactive materials, consistent with radiological consequences

The above safety functions are confirmed by following assessments which are derived from intentional aircraft impact analysis:

- The primary pressure boundary is maintained against any accidental aircraft impact.
- Structural integrity of RCCV and SFP are maintained against any accidental aircraft impact.
- In case of drop and/or strike on R/B roof, impact frequency on SFP is estimated.
- In case of other drop and/or strikes on R/B, fire propagation and shock impact are assessed to confirm the survivability of safety functions.
- Frequency of drop and/or strike on C/B roof is estimated.
- Other drop and/or strike on C/B are screened out by the protection scheme that C/B is surrounded by other concrete buildings.
- In case of drop and/or strike on T/B, frequency and consequence are analysed, assuming adequate damage.
- In case of drop and/or strike on Rw/B, frequency and consequence are analysed, assuming adequate damage.

6.7.12 External Fire

1) Definition of the hazard group
Extreme fire poses risks of the burning of parts of the plant and the resulting damage. Smoke and toxic gases may affect plant operators and certain plant systems. This section describes the characteristics of the External Fire against the nuclear power station. The design of the nuclear power station considers External Fire from site boundary of the nominated site in UK.
This hazard group consists of hazards shown in Table 6.7-12.

Table 6.7-12: External Fire Group

Hazard Group Ref. ID #	Hazard Condition	Remarks
D2	Adjacent Installations, Transport activities (Missiles, gas clouds, explosions, etc.)	-
D15	Fire	-
D34	Toxic gas (&Asphyxiates)	-

The hazard sources of External Fire are considered to be external industrial installations including stockpiles of petroleum products and other flammable liquid and gaseous chemicals as well as flammable materials, natural sources including bushes and forests and transport sources such as road, railway and ships.

A screening distance value (SDV) is determined using a conservative approach. In evaluating the potential for external fire, all potential sources lying within the SDV should be taken into consideration. Potential source of external fire hazard is considered as shown below.

- Forests
- Peat
- Storage areas for low volatility flammable materials
- Wood or plastics
- Factories that produce or store such materials
- Their transport lines
- Vegetation

Following hazard magnitude values are determined.

- Maximum heat flux
- Magnitude of hazards from burning fragments and smoke
- Duration of the fire

2) Protection policy

SSCs that deliver the safety functions are protected from External Fire by civil structure. The atmosphere inside buildings is maintained appropriately. The design principles for the scope of the civil structures in GDA are described in PCSR Chapter 10 "*Civil Works and Structures*".

3) Evaluation condition

SDVs are determined for thermal fire hazard and vapour cloud dispersion hazard, respectively. Maximum heat flux, magnitude of hazards from burning fragments and smoke, and duration of the fire will be determined.

The ventilation system for the Main Control Room (MCR) is designed to exclude smoke and toxic fumes from coming in by isolating the ventilation inlets and supplying 100% recirculation air to the MCR to maintain the function of MCR.

6.7.13 External Missile

1) Definition of the hazard group

All of civil engineering structures should consider the effect of external missiles. External missile is classified into two categories; Natural Missile and Man-made missile. Natural Missile is defined as moving object that generated by tornado. Man-made Missile is produced as a secondary consequence of nearby explosions. For both missiles, missile dimension, mass, and speed are determined.

This hazard group consists of hazards shown in Table 6.7-13.

Table 6.7-13: External Missile Group

Hazard Group Ref. ID #	Hazard Condition	Remarks
A23	Missiles from military activities	-
D24	Missiles (turbines, bottles BLEVE)	-
A38	Windblown debris	-
D2	Adjacent Installations, Transport activities (Missiles, gas clouds, explosions, etc.)	

2) Protection policy

SSCs that deliver the safety functions are protected from External Missile by civil structure. The atmosphere inside buildings is maintained appropriately. The design principles for the scope of the civil structures in GDA are described in PCSR Chapter 10 "*Civil Works and Structures*".

3) Evaluation condition

A screening distance value (SDV) is determined for Man-made Missile using a conservative approach. In evaluating the potential for explosions, all potential sources lying within the SDV should be taken into consideration.

Configurations of standard missile are used as a design basis load for the generic design. The integrity of R/B (Reactor Building) and other important SSCs should be assessed against this hazard. The control of explosive materials on the site should be addressed in SLA.

6.7.14 External Explosion

1) Definition of the hazard group
This hazard group consists of hazards shown in Table 6.7-14.

Table 6.7-14: External Explosion Group

Hazard Group Ref. ID #	Hazard Condition	Remarks
D13	External explosions (blast waves, missiles)	-

An explosion in air is accompanied by a very rapid rise in pressure and the formation of a blast wave. Large overpressures may injure people and damage equipment and buildings. External explosion is defined as any chemical reaction between solids, liquids, vapours and gases. An explosion can take the form of a deflagration, which generates moderate pressures, heat or fire, or a detonation, and which generates high near field pressures and associated drag loading but usually without significant thermal effects.

2) Protection policy
SSCs that deliver the safety functions are protected from External Explosion by civil structure. The atmosphere inside buildings is maintained appropriately. The design principles for the scope of the civil structures in GDA are described in PCSR Chapter 10 "*Civil Works and Structures*".

3) Evaluation condition
A screening distance value (SDV) should be determined by using a conservative approach. In evaluating the potential for explosions, all potential sources lying within the SDV should be taken into consideration. The SDV associated with explosions should be estimated by means of a simplified conservative approach based on the engineering relationship between the trinitrotoluene (TNT) equivalent mass and the distance. The SDV for any initiating event will be determined by calculating the scaled distance corresponding to that overpressure. This hazard strongly depends on the layout of potential sources and the spatial arrangements of the safety significant System, Structure or Component (SSC), therefore it should be considered in SLA.

6.8 Conclusion

As a result of the document survey and integration, the following 14 external hazards have been identified for assessment GDA:

- Air Temperature
- Wind
- Rainfall & Ice
- Drought
- Snow
- Electromagnetic Interference (EMI)
- Sea or River Water Temperature
- External Flooding
- Seismic Activity
- Loss of Offsite Power (LOOP)
- Aircraft Impact
- External Fire
- External Missile
- External Explosion

6.9 References

[Ref-1] Hitachi-GE, “Topic Report on External Hazard Protection”, GA91-9201-0001-00031, Rev.A

[Ref-2] Horizon (GDA Support team), "Derivation and Justification of the External Hazards for the GDA PCSR", HNP-S3-GDA-REP-00003, Revision 01

[Ref-3] WENRA RHWG, "Report Safety of new NPP designs - Study by Reactor Harmonization Working Group RHWG", March 2013.