Form10/00

HITACHI

UK ABWR

Document ID	:	GA91-9101-0101-06000
Document Number	:	AE-GD-0168
Revision Number	:	Rev.B

UK ABWR Generic Design Assessment

Generic PCSR Chapter 6 : External Hazards

Hitachi-GE Nuclear Energy, Ltd.

DISCLAIMERS

Proprietary Information

This document contains proprietary information of Hitachi-GE Nuclear Energy, Ltd. (Hitachi-GE), its suppliers and subcontractors. This document and the information it contains shall not, in whole or in part, be used for any purpose other than for the Generic Design Assessment (GDA) of Hitachi-GE's UK ABWR. This notice shall be included on any complete or partial reproduction of this document or the information it contains.

Copyright

Table of Contents

6.1 Introduction

6.1.1 Purpose of chapter 6

This PCSR Chapter 6 describes the process and methodologies used to develop the master list of external hazards to be considered for the GDA reference design. Chapter 2 "Generic Site Envelope" gives the generic site conditions for the master list. This chapter presents the derivation and justification for the master list.

6.1.2 Scope of chapter 6

The goal of this chapter is to show the list of individual and combined external hazards to be considered in the UK ABWR for the design of Structures, Systems and Components (SSC). The supporting documentation details the various studies undertaken and provides the detailed derivation and justification for the master list of external hazards.

The scope of this chapter is:

1. To perform the Hazard Identification (HAZID)
   a. Establish a comprehensive list of individual hazards based on a review of international and regulatory guidance and standards, ABWR Operational Experience (OPEX), and Relevant Good Practice (RGP).
   b. Establish the processes for the grouping and screening of individual hazards as well as their classification into GDA or the site specific phase .
   c. Establish the initial comprehensive list of combined external hazards.
   d. Establish the processes for categorisation and screening of combined external hazards.
   e. Provide the list of individual and combined external hazards so that the evaluation of the hazard condition can be performed (see PCSR Chapter 2).

2. To provide the list of individual and combined external hazards for plant designers on the relationship between the plant effect from external hazards and the UK ABWR Fundamental Safety Functions (FSF). This information provides the initial step for systematic consideration to perform the Failure Modes and Effects Analysis (FMEA) and identify initiating events to be included into the Fault Schedule.

6.2 Interface with other Documents

The structure of the document for external hazards and scope of each documents are shown in Fig. 6.2-1. PCSR chapter 6 defines the master list of external hazards which include combination events to be considered in UK ABWR SSCs design. PCSR Chapter 2 provides the generic site conditions for that master list and the justification that those values are robust and conservative enough to be used in the design. Based on these conditions, the safety margin in each SSC and the adaptability of safety case to each SSC are described in corresponding PCSR chapters "PART II: Technical Systems".

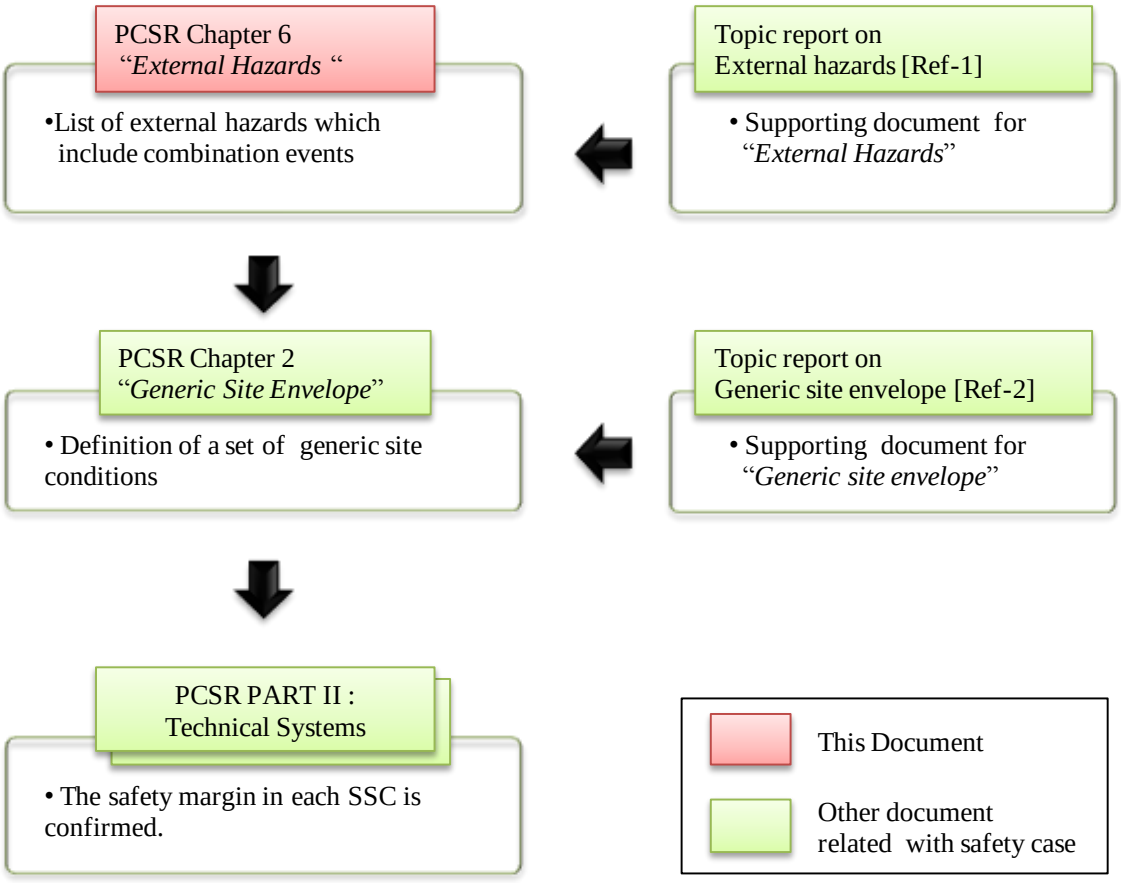

Figure 6.2-1: Safety Case Document Structure for External Hazard Assessment

6.3 Identification of Individual External Hazards

The identification process of individual external hazards is systematic in line with international good practice, which consists of the following five steps [Ref-1].

(1) Listing
(2) Grouping by denomination
(3) Grouping by plant effect
(4) Screening
(5) Classification into GDA and site specific phase

At first, a comprehensive list of individual external hazards is derived regardless of their potential effect on plant safety [Ref-3]. Then, two kinds of grouping works are developed: grouping by denomination in which a hazard's name is similar to another hazard's name or with slightly different name, and grouping by plant effect from the plant safety point of view. Next, a significantly lower mean occurrence frequency event is screened out. Then, the remaining hazard groups are classified into GDA and site specific phase considering the variability of potential hazard load among UK candidate sites.

6.3.1 Listing

The first step is to identify the comprehensive list of individual external hazard. External hazards are those natural or man-made hazards to a site and facilities, and originate outside to both the facilities site and its processes, where the duty holder has no control over the initiating event. 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. Man-made hazards are those 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. As for the origin of the master list of external hazards, its derivation and justification have been developed prior to the listing for GDA [Ref-3]. This document provided the initial basis for the production of the list of external hazards.

As per ONR SAPs [Ref-6], the list of external hazards should be comprehensive and should not be constrained by "size" or preconceived notions concerning hazard characteristics (i.e., intensity or probability). Table 6.3-1 lists the international and regulatory guidance and standards used as reference sources to inform the production of the comprehensive list from [Ref-3].

Table 6.3-1: Reference Source for Comprehensive List of External Hazards

Note: this table is an extract from [Ref-3]

No.	Reference Source
1	USNRC, "PRA Procedures Guide" (NUREG-CR-2300), January 1983
2	Pre-Construction Safety Report (Sizewell B PCSR), June 1995
3	OECD Nuclear Energy Agency (NEA), "Probabilistic Safety Analysis (PSA) of the Other External Events Than Earthquake", May 05, 2009
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), June 1991
6	IAEA, "External Events Excluding Earthquakes in the Design of Nuclear Power Plants" (IAEA Safety Guide, NS-G-1.5), 2003
7	European Utilities Requirements (EUR), Volume 2, Section 2.4, "Generic Nuclear Island Requirements: Design Basis", April, 2001
8	Swedish Nuclear Inspectorate (SKI), "Guidance for External Events Analysis", February 2003
9	HSE, "Technical Assessment Guide" 013, April 2009.
10	HSE, "Generic Design Assessment Guidance to Requesting Parties" (ONR-GDA-GD-001 Revision 4), August 2012
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.

6.3.2 Grouping by Denomination

An effective process should be applied to identify and characterise all external hazards that could affect the safety of the facility. Grouping of the various types of external events is useful for structuring the information hierarchically, and makes it more efficient to perform a complete check of the identified events.

Some hazards in the comprehensive list are duplicated with a slightly different name from another hazard [Ref-3]. For instance, Fog and Mist are slightly different but very similar in that both never occur under the ambience with no more than a certain amount of humidity. Accordingly, these two hazards are grouped into Humidity.

6.3.3 Grouping by Plant Effect

External hazards are grouped with another external hazard based on plant effect. If the potential impacts of these hazards from the point of the plant safety are similar, these hazards are grouped to avoid repetition of the same description of definition and protection. Plant effect list from external event is shown in Table 6.3-2, which is based on [Ref-7]. The applicability of this list has been reviewed in [Ref-1]. The relationship between the plant effects listed on Table 6.3-2 and the individual external hazard groups are described in section 6.5 with the corresponding UK ABWR FSFs.

Table 6.3-2: Plant Effect List

No.	Effect Category	Possible Effects
1	Structural load	The external event may affect the structure through pressure, which may disable safety functions contained.
2	Cooling/ Ventilation	The external event may affect the ventilation, which may cause partial or total loss of safety systems relying on air cooling.
3	Cooling/ Ultimate heat sink	The external event may affect the ultimate heat sink which may cause partial or total loss of secondary cooling and other safety systems relying on water cooling.
4	Power supply	The external event may affect the external power connection of the plant, and may cause loss of offsite power.
5	Plant flooding	The external event may affect the plant by disabling safety systems contained or by undermining the structure.
6	Thermal load	The external event may affect the plant by disabling safety systems contained.
7	Electric	The external event has indirect effects on the plant by generating electrical or magnetic fields, which may potentially affect transmission of power supply or control signals to safety systems.
8	Other direct impact	In a few cases, the event may work in a way that is not covered by the general categories. An example is plant isolation.

6.3.4 Screening

Any generic type of hazard with a total frequency that is demonstrably below once in ten million years may be excluded from the fault analysis. According to SAP [Ref-6], a cut off frequency of 10^{-7} pa can be applied to remove the hazard purely on the basis of frequency of occurrence. The applicability of the screening has been reviewed for each hazard [Ref-1].

6.3.5 Classification of Hazards into either Generic Design Assessment (GDA) or Site Specific Phase

It would be reasonable to consider the protection against hazards on a site by site basis if there is great variability of potential hazard loads among new-built nuclear candidate sites in UK. Hazards are reviewed and classified into GDA or site specific phase considering whether the dependency for the site specific information is required to categorise the hazards.

6.3.6 Master List of Individual External Hazards

As a result of the process from section 6.3.1 to 6.3.5, the list of individual external hazard groups is derived as shown in Table 6.3-3 below. Fourteen individual external hazard groups have been selected for GDA and remaining seven individual external hazard groups have been selected for site specific phase [Ref-1]. Definition for the fourteen GDA hazard groups and relevant combined hazards are described in the section 6.6 of this chapter.

Table 6.3-3: Individual Hazard Group List* [Ref-1].

Hazard Group #	Hazard Group	Treatment
1	Air Temperature [A10][A30] [CH 106] [A3][A20]	GDA
2	Wind [A4][A3][A20]	
3	Rainfall & Ice [A6][A8][A14][A15][A16][A22][A3][A20]	
4	Drought [C1][A3][A20]	
5	Snow [A39][A44][A3][A20]	
6	Electromagnetic Interference (EMI) [A17][D7] [A43][D8][D27]	
7	Sea or River Water Temperature [A32][A3][A20]	
8	External Flooding [A26][A29][B21][C3][C4][C9][C11][A22][A3][A20]	
9	Seismic Activity [B16][B4][B7][B36][B37][B15]	
10	Loss of Offsite Power [D19]	
11	Aircraft Impact [D1]	
12	External Fire [D2][D15][D34]	
13	External Missile [D23][D24][A38][D2]	
14	External Explosion [D13]	
15	Cloud / Storms (Ash, Dust, Sand, Salt) [A34][A25][A28]	Site specific phase
16	Ground Condition [A31][B1][B2][B3][B9][B11][B12][B14][B17][B18][B19][B20] [B30] [D10][D22][D37][D40][F3]	
17	External Transport Impacts [D33]	
18	Industrial Environment [D2][D3][D20][D25][D26][D31][D32][D36][F1]	
19	Water based Biological Fouling [E4][E2][E6][E8][E16]	
20	Land & Air-based Biological Fouling [E1][E2][E4][E6]	
21	Flotsam/ Jetsam/Log jam [D4][D41][D42]	
22	Extra-terrestrial object [A19][D29]	Screen out based on occurrence frequency [Ref-1]

*ID Numbers in [ ] is Hazard ID as per Topic Report on External Hazards [Ref-1] and Topic Report on Combined External Hazards [Ref-4].

6.4 Identification of Combined External 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 individual hazards in section 6.3 are considered.

The identification process of combined external hazards is systematic and in line with international good practice such as IAEA [Ref-8], ASME [Ref-9] and SKI [Ref-10], which consists of the following steps covered in the topic report of combination hazards [Ref-4]:

(1) Listing
(2) Categorisation
(3) Screening

In the second (Categorisation) and third (Screening) steps, the hierarchical consideration is adapted to exhaustively and effectively check all the combinations.

6.4.1 Listing

This process starts with a list of potential individual external events identified in section 6.3. To keep completeness of this process, all the combination of the derived individual external hazards of GDA are considered. Cross checking matrix listing GDA individual hazard groups in both horizontal and vertical axis is provided so as not to lose any hazard group combinations. As discussed in section 6.3, each group contains at the very least two or more than one individual hazard basically, thus some individual hazard combinations in the same hazard group remain in the review of group cross checking matrix. The individual hazard combinations in the same group are also reviewed additionally. This hierarchical consideration can lead to exhaustively and effectively checking of the combinations.

6.4.2 Categorisation

All the combination of derived individual external hazards in section 6.3 are reviewed and classified into three categories based on initiating correlation as shown below. This categorisation is hierarchically applied to the two steps described in section 6.4.1 above. Fundamental treatments for the combined hazard load and the occurrence frequency will be set for each category.

(1) Combination Category I: Consequential hazards

One hazard originates (or causes) the other hazard consecutively. As an example, a strong earthquake may cause a Tsunami. Superimposed hazard effect should be considered in UK ABWR design.

(2) Combination Category II: Coincidental hazards

Occurrences of the events are not independent. This type has a common cause or individual initiating event. In this event, more than one hazard is derived from the same meteorological conditions.

(3) Combination Category III: Independent hazards

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

6.4.3 Screening

There are a significantly large number of hazard combinations. In order to arrive at a manageable amount of potential combination events, applications of screening are reviewed and applied for each event. The screening criteria are shown in Table 6.4-1. These criteria are derived based on international RGP [Ref-7, 8, 9, and 10] and reviewed the adaptability to the UK regulatory approach, i.e. SAP requirement [Ref-6], and the compatibility of the design basis carefully [Ref-4]. The result of categorisation (section 6.4.2) and screening (section 6.4.3) process fully reflects the input from specialists in addition to the careful review and study based on engineering judgment [Ref-4].

Table 6.4-1: Proposed Qualitative Screening Criteria for Combinations Hazards

Screening Criterion No.	Description
SC1	The event is of equal or lesser damage potential than similar events for which the plant has been designed.
SC2	The event has a significantly lower mean frequency of occurrence than another event that has been screened, and the event could not result in worse consequences than the other screened event.
SC3	The event cannot occur at the site or close enough to the site to affect the plant.
SC4	The event is included in the definition of another event.
SC5	The event is slow in developing such that it can be demonstrated that there is sufficient time to eliminate the source of the threat or provide an adequate response.
SC6	The event does not cause an initiating event (including the need for a controlled shutdown) as well as safety system function loss (es) needed for the event.
SC7	The consequences to the plant do not require the actuation of front-line systems.
SC8	The events occur independently of each other in time AND The probability of simultaneous occurrence is low.
SC9	The events do not occur independently in time AND Multiple events included in definition of a single event, which is analysed for the plant.
SC10	The events do not occur independently in time AND The events affect the same plant safety function. AND The combined effect on the safety function is not greater that the effect from most severe of the single events involved
SC11	The event frequency/frequency of exceedance on their hazard curve is demonstrably below once in ten million years per annum.

6.4.4 Master List of Combined External Hazards

As a result of the process from section 6.4.1 to 6.4.3, the list of combined external hazards as classified into Cat I and II is shown in Table 6.4-2 below. Identified combined hazards are described in relevant section 6.6 and in further details in the Topic Report for Combination of Hazards [Ref-4].

The Cat III external events remain [HOLD for STEP 4]. The following reason will provide the basis for the next stage of screening for the Cat III combined hazards:

In general, the higher the frequency with which the hazard occurs, the less the load affects the plant. The graphical variability of hazard load versus hazard frequency of occurrence is so called the hazard curve. In the case of the high occurrence frequency and low load, the plant safety can be maintained by the protection from the individual hazard event. For each independent external event, there is duration time (or recovery time) for which the plant can recover from a hazard, thus the smaller the recovery time is, the smaller the influence is on plant. This means that when the recovery time is short and another external event occurs, the plant has already recovered from the initial one. Thus combination does not occur. Accordingly, the case of the combined hazard may be screened out by SC1.

In case of low occurrence frequency and high load, the occurrence frequency of this combined event is less than or equal to 10^{-7} without the relation to the recovery time. Accordingly, in this case the combined hazard may be screened out by SC2.

Table 6.4-2: Screened In Combined Hazard List

CH ID#	Hazard1	Hazard2	CH Category	Further treatment
19	Wind	External flooding	I	Section 6.6.8
24	Wind	External missile	I	Section 6.6.13
27	Rainfall & Ice	Snow	II	Section 6.6.5
30	Rainfall & Ice	External flooding	I	Section 6.6.8
48	Snow	Sea or River water temperature	II	Section 6.6.7
49	Snow	External flooding	I	Section 6.6.8
71	External flooding	Seismic Activity (Earthquake)	I	Section 6.6.9
77	Seismic Activity (Earthquake)	Loss of Offsite Power (LOOP)	I	Section 6.6.9
106	Humidity	Temperature Extremes (Air)	I	Section 6.6.1
107	Hail, Sleet, Snow and Icing	Ice (Frazil)	II	Section 6.6.3
108	Hail, Sleet, Snow and Icing	Ice (Rime)	II	Section 6.6.3
109	Hail, Sleet, Snow and Icing	Ice (Barriers)	II	Section 6.6.3
110	Hail, Sleet, Snow and Icing	Frost, soil frost	II	Section 6.6.3
111	Hail, Sleet, Snow and Icing	Rainfall (extreme) & Intense precipitation	II	Section 6.6.3
112	Ice (Frazil)	Ice (Rime)	II	Section 6.6.3
113	Ice (Frazil)	Ice (Barriers)	II	Section 6.6.3
114	Ice (Frazil)	Frost soil frost	II	Section 6.6.3
116	Ice (Rime)	Ice (Barriers)	II	Section 6.6.3
117	Ice (Rime)	Frost soil frost	II	Section 6.6.3
119	Ice (Barriers)	Frost soil frost	II	Section 6.6.3
132	Low / High Sea water level	Storm surge	I	Section 6.6.8
133	Low / High Sea water level	Tidal effects (Flooding)	I	Section 6.6.8
141	Storm surge	Groundwater	I	Section 6.6.8
143	Storm surge	Dam Failure	I/III	Section 6.6.8

CH ID#	Hazard1	Hazard2	CH Category	Further treatment
144	Storm surge	Pipeline Accident (Gas, Oil, Water, etc.)	I/III	Section 6.6.8
148	Tidal effects (Flooding)	Dam Failure	I/III	Section 6.6.8
152	Waves	Dam Failure	I/III	Section 6.6.8
153	Waves	Pipeline Accident (Gas, Oil, Water, etc.)	I/III	Section 6.6.8
154	Groundwater	High tide, high lake level, or high river stage	I/III	Section 6.6.8
155	Groundwater	Dam Failure	I/III	Section 6.6.8
156	Groundwater	Pipeline Accident (Gas, Oil, Water, etc.)	I/III	Section 6.6.8
158	High tide, high lake level, or high river stage	Pipeline Accident (Gas, Oil, Water, etc.)	I/III	Section 6.6.8
159	Dam Failure	Pipeline Accident (Gas, Oil, Water, etc.)	I/III	Section 6.6.8
161	Seismic Activity (Earthquake)	Faults	I	Section 6.6.9
175	Fire	Adjacent Installations, Transport activities (Missiles, gas clouds, explosions, etc.)	I	Section 6.6.12
176	Fire	Toxic gas (& Asphyxiates)	I	Section 6.6.12
177	Adjacent Installations, Transport activities (Missiles, gas clouds, explosions, etc.)	Toxic gas (& Asphyxiates)	I	Section 6.6.12

6.5 The Relationship between Safety Functions and External Hazards

6.5.1 Safety Functions

UK ABWR FSFs are described in PCSR Chapter 5 sub-section 5.4 "*Categorisation and Classification of Structures, Systems and Components (SSCs)*" as below:

(1) Control of Reactivity

(2) Fuel Cooling

(3) Long Term Heat Removal

(4) Confinement/Containment of radioactive materials

These ABWR FSFs should be maintained against external hazard events. The UK ABWR SSCs are to be designed to withstand the stipulated generic external hazard conditions and hazards in combinations.

6.5.2 Plant Effect Matrix

The safety functions in section 6.5.1 are confirmed by the compliance with the safety cases. The safety cases should be satisfied in each design of SSC considering the effect of external hazards appropriately.

The relationship between the plant effect by external hazards groups and the safety functions is shown in Table 6.5-1. There are two rows as headers of this table. The first row shows the plant effects directly derived from Table 6.3-2. The second row shows the corresponding FSFs listed in section 6.5.1. Multiple safety functions may relate to each plant effect.

Table 6.5-1 also shows fourteen GDA individual external hazard groups accompanied with plant effects and safety functions. The corresponding legends for Table 6.3-2 are as follows: "X" mean "affects" and "-" mean "does not affect". Relevant plant effects are described within the following sub-sections 6.6 for each hazard group.

Table 6.5-1: Relationship between the Plant Effect by External Hazards Groups and Safety Functions

Hazard Gr.	Plant effect	Structural Load	Cooling /Ventilation	Cooling /UHS	Power Supply	Plant flooding	Thermal load	Electric	Other direct impact (ex. Plant isolation)
	ABWR safety fuctions (see section 6.5.1)	(4)	(2)(3)(4)	(2)(3)(4)	(2)(3)	(3)(4)	(4)	(3)(4)	(3)(4)
1	Air Temperature	X	X	X	-	-	-	-	-
2	Wind	X	-	-	-	-	-	-	-
3	Rainfall & Ice	X	-	X	-	X	-		-
4	Drought	-	-	X	-	-	-	-	-
5	Snow	X	-	X	-	X	-	-	-
6	Electromagnetic Interference (EMI)	-	-	-	-	-	-	X	-
7	Sea or River Water Temperature	-	-	X	-	-	-	-	-
8	External Flooding	X	-	X	X	X	-	-	-
9	Seismic Activity	X	X	X	X	-	-	X	-
10	Loss of Offsite Power (LOOP)	-	-	-	X	-	-	-	-
11	Aircraft Impact	X	X	-	-	-	X	X	-
12	External Fire	-	-	-	-	-	X	-	X
13	External Missile	X	-	-	-	-	-	-	-
14	External Explosion	X	-	-	-	-	-	-	-

6.6 Hazard Definition and General Protection

This section presents the definition of hazard group and the reference of general protection for each identified hazard group. Relevant combined hazard which is derived in section 6.4 are also described in each subsection.

6.6.1 Air Temperature

1) Hazard definition

(a) Plant effects in this hazard group

The plant effects (see Table 6.5-1) in this hazard group are;

- Structural load
- Cooling/Ventilation
- Cooling/UHS

There may be no direct nuclear safety risk from extreme high and low air temperatures, however extreme temperatures pose potential failure of cooling or ventilation plant and brittle fracture of steel structures, respectively. Low temperatures may also threaten cooling water supplies through freezing. This event is considered as an event consequence in Snow (section 6.6.5).

(b) Individual Hazards

Table 6.6-1 shows the individual hazards in this group. The generic design of the nuclear power station considers the extreme air temperature conditions of the nominated UK sites. Ten thousand years return periods for maximum and minimum temperatures are considered. The effects of climate change are also taken into consideration.

Table 6.6-1: Air Temperature Group

Hazard 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.

(c) Combined Hazards [Ref-4]

The combined hazards to be considered in this hazard group are shown in Table 6.6-2. Air temperature and humidity are one of the dependency parameters of enthalpy. Enthalpy is used in the design of heating and ventilation systems.

Table 6.6-2: Combined Hazards in Air Temperature Group

CH ID #*	Hazard 1	Hazard 2	CH Categorisation
106	Humidity	Temperature Extremes (Air)	I

2) General protection

SSCs that deliver the FSFs 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)*", respectively.

6.6.2 Wind

1) Hazard definition

(a) Plant effects in this hazard group

The plant effect (see Table 6.5-1) in this hazard group is;

- Structural load

Tornadoes are violent funnel shaped vortices of wind created by certain meteorological conditions which damage properties through the pressures (both negative and positive) generated by the vortex itself and the associated wind-born debris. a Flying debris generated by strong wind including tornadoes and tropical storms is considered as an event consequence in External missile (section 6.6.13) as natural missile.

(b) Individual Hazards

Table 6.6-3 shows the individual hazards in this group. The generic design of the nuclear power station considers the weather conditions of the nominated UK sites. Ten thousand years return periods for maximum wind load are considered. The effects of climate change are also taken into consideration.

Table 6.6-3: Wind Group

Hazard ID #	Hazard Condition	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.

(c) Combined Hazards [Ref-4]

The combined hazards to be considered within this hazard group do not exist. Combination of wind load and wind generated missile impact are treated in External missile group (section 6.6.13).

2) General protection

SSCs that deliver the safety functions are protected from wind load by civil structure. Accordingly, any structures containing SSCs are considered to withstand wind loading. The presences of dominant openings are also considered. 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.

6.6.3 Rainfall & Ice

1) Hazard definition

(a) Plant effects in this hazard group

The plant effects (see Table 6.5-1) in this hazard group are;

- Structural load
- Cooling/UHS
- Plant flooding

Frozen substance such as ice may threaten cooling water supplies. This event is considered as an event consequence in Snow (section 6.6.5). Heavy rainfall may cause the elevation of sea water level. This event is considered as an event consequence in External flooding (section 6.6.8).

(b) Individual Hazards

Table 6.6-4 shows the individual hazards in this group. Rainfall includes snow, sleet and hail as well as small amounts of ice such as frazil, rime and frost. Those are melted and measured as total precipitation collectively. The generic design of the nuclear power station considers the weather conditions of the nominated UK sites. Ten thousand years return periods for maximum and minimum precipitation are considered. The effects of climate change are also taken into consideration.

Table 6.6-4: Rainfall & Ice Group

Hazard 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.

(c) Combined Hazards [Ref-4]

The combined hazards to be considered in this hazard group are shown in Table 6.6-5.

These combined events are classified as Combination Category II: Coincidental hazards, thus the occurrence of these meteorological events are not independent. These effects on NPP are treated as precipitation collectively, too.

Table 6.6-5: Combined Hazards in Rainfall & Ice Group

CH ID #	Hazard 1	Hazard 2	CH Categorisation
107	Hail, Sleet, Snow and Icing	Ice (Frazil)	II
108	Hail, Sleet, Snow and Icing	Ice (Rime)	II
109	Hail, Sleet, Snow and Icing	Ice (Barriers)	II
110	Hail, Sleet, Snow and Icing	Frost, soil frost	II
111	Hail, Sleet, Snow and Icing	Rainfall (extreme) & Intense precipitation	II
112	Ice (Frazil)	Ice (Rime)	II
113	Ice (Frazil)	Ice (Barriers)	II
114	Ice (Frazil)	Frost soil frost	II
116	Ice (Rime)	Ice (Barriers)	II
117	Ice (Rime)	Frost soil frost	II
119	Ice (Barriers)	Frost soil frost	II

2) General protection

SSCs that deliver the safety functions are protected from Rainfall & Ice by the civil structure. The atmosphere inside buildings is maintained appropriately. Heavy and long rainfall may cause erosion on exposed SSCs and civil structure. 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*".

6.6.4 Drought

1) Hazard definition

(a) Plant effects in this hazard group

The plant effect (see Table 6.5-1) in this hazard group is;

- Cooling/UHS

This hazard group may affect the coolant water level in the river or reservoir. It also may affect the seawater level. This event is considered as an event consequence in External flooding (section 6.6.8).

(b) Individual Hazards

Table 6.6-6 shows the individual hazards in this group. A severe drought may cause drawdown of water level. The drawdown poses the loss of cooling water.

Table 6.6-6: Drought Group

Hazard 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.

(c) Combined Hazards [Ref-4]

The combined hazards to be considered within this hazard group do not exist.

2) General protection

See section 6.6.8.

6.6.5 Snow

1) Hazard definition

(a) Plant effects in this hazard group

The plant effects (see Table 6.5-1) in this hazard group are;

- Structural load
- Cooling/ UHS
- Plant flooding

Melted snow is considered as the event consequence of rainfall & ice (section 6.6.3). The blockage of the water intake by ice is considered in Sea or River Water Temperature (section 6.6.7).

Snowmelt following a very cold winter period with lying snow may cause flooding. This is considered in External flooding (section 6.6.8). LOOP due to the ice formation is considered in Loss of Off-Site Power (section 6.6.10).

(b) Individual Hazards

Table 6.6-7 shows the individual hazards in this group. The generic design of the nuclear power station considers the snow load of the nominated UK sites. Ten thousand years return periods for maximum and minimum precipitation are considered. The effects of climate change are also taken into consideration.

Table 6.6-7: Snow Group

Hazard 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.

(c) Combined Hazards [Ref-4]

The combined hazards to be considered in this hazard group are shown in Table 6.6-8. The weight of snow may increases if rainfall occurs on the accumulated snow.

Table 6.6-8: Combined Hazards in Snow Group

CH ID #	Hazard 1	Hazard 2	CH Categorisation
27	Rainfall & Ice	Snow	II

2) General protection

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*".

6.6.6 Electromagnetic Interference (EMI)

1) Hazard definition

(a) Plant effects in this hazard group

The plant effect (see Table 6.5-1) in this hazard group is;

- Electric

EMI can cause disturbances that affect electrical systems by interrupting, obstructing or degrading their performance. EMI can originate from both natural sources (e.g. lightning) and artificial sources (e.g. communication systems).

(b) Individual Hazards

Table 6.6-9 shows the individual hazards in this group.

Though A43: Solar flares, D8: Electromagnetic pulse and D27: Radio-frequency interference are listed in Table 6.3-3, these are enveloped into D7 [Ref-4].

Table 6.6-9: EMI Group

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

(c) Combined Hazards [Ref-4]

The combined hazards to be considered within this hazard group do not exist.

2) General protection

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 is discussed in PCSR Chapter 7"*Internal hazards*".

6.6.7 Sea or River Water Temperature

1) Hazard definition

(a) Plant effects in this hazard group

The plant effect (see Table 6.5-1) in this hazard group is;

- Cooling/UHS

Sea and air are key ultimate heat sink (UHS) of UK ABWR. The UHS 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).

(b) Individual Hazards

Table 6.6-10 shows the individual hazards in this group. The generic design of the nuclear power station considers the seawater temperature of the nominated UK sites. Ten thousand years return periods for maximum and minimum seawater temperatures are considered. The effects of climate change are also taken into consideration.

Table 6.6-10: Sea or River Water Temperature Group

Hazard 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.

(c) Combined Hazards [Ref-4]

The combined hazards to be considered in this hazard group are shown in Table 6.6-11. Snowmelt sometimes may affect low Sea or River water temperature. And there may be possible that many sheets of ice gather at the intake of the water.

Table 6.6-11: Combined Hazards in Air Temperature Group

CH ID #	Hazard 1	Hazard 2	CH Categorisation
48	Snow	Sea or River water temperature	II

2) General protection

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. The detail is described in PCSR Chapter 16 "*Auxiliary Systems*".

6.6.8 External Flooding

1) Hazard definition

(a) Plant effects in this hazard group

The plant effects (see Table 6.5-1) in this hazard group are;

- Structural load
- Cooling/UHS
- Power Supply
- Plant flooding

The safety of nuclear power plants can be seriously affected by flooding. External flooding poses potential failure of structures, systems and components by the infiltration of water into internal areas of the plant.

(b) Individual Hazards

Table 6.6-12 shows the individual hazards in this group. 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. Storm surges are short-lived local increases in water level above that of the tide and are driven by wind and atmospheric pressure gradients. There are some hazards whose influence greatly depends on the site location. In this hazard group, C15: Dam failure and D26: Pipeline Accident (Gas, Oil, Water, etc.) are regarded as such because there is the case that the facilities such as Dam or Pipeline exist very close to the plant or pretty far from the plant.

The maximum flooding level is defined as the highest of the mean sea level Above Ordnance Datum (AOD). Ten thousand years return periods for maximum and minimum AOD are considered. The effects of climate change are also taken into consideration.

(c) Combined Hazards [Ref-4]

The combined hazards to be considered in this hazard group are shown in Table 6.6-13. 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. Basically, all the combinations of single events listed in the table above are considered [Ref-4]. However, because some combinations are not realistic or are bounded by the single event, the indispensable combinations are only listed.

2) General protection

UK ABWR is designed based on 'dry site' conditions where all items important to safety are constructed above the level of the design basis flood. 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*". The protection policy of the power supply system such as the arrangement of the emergency power supply car is described in PCSR Chapter 15 "*Electrical Power Supplies*". This hazard group consists of hazards shown in Table 6.7-8.

Table 6.6-12: External Flooding Group

Hazard ID #	Hazard Condition	Remarks
A26	Low / High seawater 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	To be considered in SLA
D26	Pipeline Accident (Gas, Oil, Water, etc.)	To be considered in SLA
A3	Climate Change	This effect is considered in other hazards.
A20	Extreme Meteorological Conditions	This effect is considered in other hazards.

Table 6.6-13: Combined Hazards in External Flooding Group

CH ID#	Hazard1	Hazard2	CH Category
19	Wind	External flooding	I
30	Rainfall & Ice	External flooding	I
49	Snow	External flooding	I
132	Low / High Seawater level	Storm surge	I
133	Low / High Seawater level	Tidal effects (Flooding)	I
141	Storm surge	Groundwater	I
143	Storm surge	Dam Failure	I/III
144	Storm surge	Pipeline Accident (Gas, Oil, Water, etc.)	I/III
148	Tidal effects (Flooding)	Dam Failure	I/III
152	Waves	Dam Failure	I/III
153	Waves	Pipeline Accident (Gas, Oil, Water, etc.)	I/III
154	Groundwater	High tide, high lake level, or high river stage	I/III
155	Groundwater	Dam Failure	I/III
156	Groundwater	Pipeline Accident (Gas, Oil, Water, etc.)	I/III
158	High tide, high lake level, or high river stage	Pipeline Accident (Gas, Oil, Water, etc.)	I/III
159	Dam Failure	Pipeline Accident (Gas, Oil, Water, etc.)	I/III

6.6.9 Seismic Activity

1) Hazard definition

(a) Plant effects in this hazard group

The plant effect (see Table 6.5-1) in this hazard group is;

- Structural load
- Cooling / Ventilation
- Cooling / UHS
- Power supply
- Electric

The safety of nuclear power plants can be affected by seismic activity. Seismic activity poses potential failure of structures, systems and components by ground motion.

(b) Individual Hazards

Table 6.6-13 shows the individual hazards in this group. Evaluation condition of B4, B36, B37 and B15 are described in PCSR Chapter 2"*Generic Site Envelope*". Effects of B7 depend on the site condition. Therefore, these effects are considered in Site License phase.

Table 6.6-13: Seismic Activity Group

Hazard ID #	Hazard Condition	Remarks
B16	Seismic Activity (Earthquake)	-
B4	Dynamic Compaction (Earthquakes)	Described in PCSR Chapter 2 "*Generic Site Envelope*".
B7	Faults	This effect is considered in site specific phase.
B36	Minimum Shear Wave Velocity	Described in PCSR Chapter 2 "*Generic Site Envelope*".
B37	Minimum Static Bearing Capacity	Described in PCSR Chapter 2 "*Generic Site Envelope*".
B15	Liquefaction (Earthquake)	Described in PCSR Chapter 2 "*Generic Site Envelope*".

(c) Combined Hazards [Ref-4]

The combined hazards to be considered in this hazard group are shown in Table 6.6-14. The combination event consisting of the Seismic activity, the external flooding and LOOP is separately considered in Fukushima accident countermeasures in PCSR chapter 26.

Table 6.6-14: Combined Hazards in Seismic Activity Group

CH ID#	Hazard1	Hazard2	CH Category
71	External flooding	Seismic Activity (Earthquake)	I
77	Seismic Activity (Earthquake)	Loss of Off-Site Power (LOOP)	I
161	Seismic Activity (Earthquake)	Faults	I

2) General protection

Seismic loads acting on SSCs are evaluated by performing seismic analysis using ground motion defined in PCSR Chapter 2 "*General Site Envelope*". Each SSC is classified into seismic category. Details are described in PCSR Chapter 5 "*General Design Aspects*", and SSCs are to be designed to withstand seismic loads corresponding to seismic category of each SSC.

6.6.10 Loss of Off-Site Power

1) Hazard definition

(a) Plant effects in this hazard group

The plant effect (see Table 6.5-1) in this hazard group is;

- Power Supply

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 LOOP.

(b) Individual Hazards

Table 6.6-15 shows the individual hazards in this group. Loss of off-site power (LOOP) is generally defined as a simultaneous loss of electrical power from offsite electrical power grid that causes emergency power generators to start and supply power to the buses.

Table 6.6-15: LOOP Group

Hazard ID #	Hazard Condition	Remarks
D19	LOOP	-

(c) Combined Hazards [Ref-4]

Meteorological and hydrological phenomena may simultaneously affect all the structures, systems and components important to safety on a nuclear installation site.

2) General protection

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). This will be discussed in Fault study. The design principles for the scope of the electrical power supply system GDA are described in PCSR Chapter 15"*Electrical Power Supplies*".

6.6.11 Aircraft Impact

1) Hazard definition

(a) Plant effects in this hazard group

The plant effects (see Table 6.5-1) in this hazard group are;

- Structural load
- Cooling/Ventilation
- Thermal load
- Electric

The following direct and indirect effects of the aircraft crash are considered:

- Effects of direct and secondary impacts on mechanical resistance of safety structures and systems required to bring and maintain the plant in a safe state after airplane crash;
- Effects of vibrations on safety structures and systems required to bring and maintain the plant in a safe state after airplane crash;
- Effects of combustion and/or explosion of airplane fuel on the integrity of the necessary structures and on the systems required to bring and maintain the plant in a safe state after airplane crash.

(b) Individual Hazards

Table 6.6-16 shows the individual hazards in this group. Intentional aircraft impact is also considered in UK ABWR design.

Table 6.6-16: Aircraft Impact Group

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

(c) Combined Hazards

Aircraft impact assessment is discussed separately.

2) General protection

For accidental aircraft impact, crash frequency is calculated as the total predicted frequency of aircraft crash, including helicopters and other airborne vehicles, on or near any facility housing structures, systems and components important to review the need to develop design assessments/ undertake protective measures.

Intentional aircraft impact is assessed as a Beyond Design Basis (BDB) event by realistic approach with the following assumptions:

- Best estimate material properties and realistic failure criteria are applied.
- Other coincident failure of plant and equipment is not considered.
- Keep the sufficient margin to cliff edge effects.

The objective of this protection is to prevent core melt and therefore not to cause more than a minor radiological impact as noted in the WENRA RHWG report [Ref-5]. Safety functions required to bring and maintain the plant in a safe state after such a crash are designed and protected adequately.

6.6.12 External Fire

1) Hazard definition

(a) Plant effects in this hazard group

The plant effect (see Table 6.5-1) in this hazard group is;

- Thermal load
- Other direct impact (plant isolation)

Extreme fire poses risks of the burning of parts of the plant and the resulting damage. Two types of fire modes might produce thermal effects: pool fire and fireball. The pool fire is defined as a turbulent diffusion fire burning above a horizontal pool vaporising flammable material, and generating moderate heat or fire. Fireballs may result from the ignition of a vapour cloud, where buoyancy forces predominate as part of a Boiling Liquid Expanding Vapour Explosion (BLEVE) when a vessel ruptures after it has been engulfed in fire or has been subjected to a directed flame. The fireball generates high near field pressures and associated drag loading but usually without significant thermal effects.

(b) Individual Hazards

Table 6.6-17 shows the individual hazards in this group. 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.

Table 6.6-17: External Fire Group

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

(c) Combined Hazards [Ref-4]

The combined hazards to be considered in this hazard group are shown in Table 6.6-18. One of the sources of Toxic gases and Asphyxiates is fires; however, pipe accidents leading to gas leakages should be taken into consideration. Adjacent installations, transport activities in the vicinity can lead to release of toxic gases and asphyxiates and impact plant. Because it is a site specific issue, it will be studied by site specific phase.

Table 6.6-18: Combined Hazards in External Fire Group

CH ID #	Hazard 1	Hazard 2	CH Categorisation
175	Fire	Adjacent Installations, Transport activities (Missiles, gas clouds, explosions, etc.)	I
176	Fire	Toxic gas (& Asphyxiates)	I
177	Adjacent Installations, Transport activities (Missiles, gas clouds, explosions, etc.)	Toxic gas (& Asphyxiates)	I

2) General protection

A screening distance value (SDV) where the hazard poses a credible threat to nuclear safety is determined using a conservative approach and described in PCSR Chapter 2"*Generic Site Envelope*". The hazard sources in the vicinity of the candidate site that fall outside the SDV are dismissed. For the remaining hazard sources, the occurrence frequency and its load are assessed.

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*".

6.6.13 External Missile

1) Hazard definition

(a) Plant effects in this hazard group

The plant effect (see Table 6.5-1) in this hazard group is;

- Structural load

SSCs that deliver the safety functions are protected from external missile including tornado/hurricane by civil structure.

(b) Individual Hazards

Table 6.6-19 shows the individual hazards in this group. External missile is classified into two categories; natural missile and man-made missile. Natural missile is defined as windblown debris that generated by strong wind including tornadoes. High horizontal wind-speed together with its characteristic but lesser vertical speeds may produce unusual and dangerous airborne missiles. Man-made missile is produced as a secondary consequence of nearby explosions. Industrial environments contain many potential sources of missiles; in a generic sense, any high speed rotating machinery can destructively malfunction and emit high energy projectiles of significant mass, pressure vessels or pressurised pipe work can fail explosively and emit missiles in the form of fragments, explosions can energetically impel objects to generate missile hazards.

Table 6.6-19: External Missile Group

Hazard ID #	Hazard Condition	Remarks
D23	Missiles from military activities	-
D24	Missiles (turbines, bottles BLEVE)	-
A38	Windblown debris	-
D2	Adjacent Installations, Transport activities (Missiles, gas clouds, explosions, etc.)	

(c) Combined Hazards [Ref-4]

The combined hazards to be considered in this hazard group are shown in Table 6.6-20. Flying debris generated by strong wind including tornado and the tropical storms should be considered in UK ABWR design.

Table 6.6-20: Combined Hazards in External Missile Group

CH ID #	Hazard 1	Hazard 2	CH Categorisation
24	Wind	External missile	I

2) General protection

For natural missiles, missile generation by the design basis wind load is defined in PCSR Chapter 2"*Generic Site Envelope*" to ensure the safety of nuclear power plant. For man-made missile, a screening distance value (SDV) where the hazard poses a credible threat to nuclear safety is determined using a conservative approach in PCSR Chapter 2"*Generic Site Envelope*". The hazard sources in the vicinity of the candidate site that fall outside the SDV are dismissed. For the remaining hazard sources, the occurrence frequency and its load are assessed.

SSCs that deliver the safety functions are protected from external missile including tornado/hurricane 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*"

6.6.14 External Explosion

1) Hazard definition

(a) Plant effects in this hazard group

The plant effect (see Table 6.5-1) in this hazard group is;

- Structural load

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

(b) Individual Hazards

Table 6.6-21 shows the individual hazards in this group. An explosion in air is accompanied with 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.

Table 6.6-21: External Explosion Group

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

(c) Combined Hazards [Ref-4]

The combined hazards to be considered within this hazard group do not exist.

2) General protection

A screening distance value (SDV) where the hazard poses a credible threat to nuclear safety is determined using a conservative approach in PCSR Chapter 2"*Generic Site Envelope*. The hazard sources in the vicinity of the candidate site that fall outside the SDV are dismissed. For the remaining hazard sources, the occurrence frequency and its load are assessed.

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*

6.7 Conclusion

As a result of the document survey and integration, the following fourteen external hazards have been selected for assessment in GDA:

1 - Air temperature
2 - Wind
3 - Rainfall & Ice
4 - Drought
5 - Snow
6 - Electromagnetic interference (EMI)
7 - Sea or River water temperature
8 - External flooding
9 - Seismic activity
10 - Loss of Off-Site power (LOOP)
11 - Aircraft impact
12 - External fire
13 - External missile
14 - External explosion

The following seven individual external hazard groups have been selected for site specific phase:

15 - Cloud / Storms (Ash, Dust, Sand, Salt)
16 - Ground condition
17 - External transport impacts
18 - Industrial environment
19 - Water based biological fouling
20 - Land & air-based biological fouling
21 - Flotsam/ Jetsam/Log jam

Relevant individual hazards and combined hazards are defined for each group.

6.8 References

[Ref-1] Hitachi-GE, “Topic Report on External Hazard Protection”, GA91-9201-0001-00031, AE-GD-0126, Rev.2 , May 2015

[Ref-2] Hitachi-GE, “Topic Report on Generic Site Envelope”, GA91-9201-0001-00030, XE-GD-0183, Rev. A, June 2014

[Ref-3] Horizon, "Derivation and Justification of the External Hazards for the GDA PCSR", HNP-S3-GDA-REP-00003, Rev.01, July 2014

[Ref-4] Hitachi-GE, “Topic Report on Combined External Hazards”, GA91-9201-0001-00118, AE-GD-0201, Rev.0 , May 2015

[Ref-5] WENRA RHWG, "Report Safety of new NPP designs - Study by Reactor Harmonization Working Group RHWG", March 2013.

[Ref-6] Office for Nuclear Regulation, “Safety Assessment Principles for Nuclear Facilities, 2014 Edition”, Rev.0

[Ref-7] Swedish Nuclear Inspectorate (SKI), “Guidance for External Events Analysis”, February 2003

[Ref-8] International Atomic Energy Agency, Development and Application of Level 1 Probabilistic Safety Assessment for Nuclear Power Plants, SSG-3, April 2010.

[Ref-9] The American Society of Mechanical Engineers, Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications, ASME/ANS RA-Sa–2009, February 2009.

[Ref-10] Michael Knochenhauer and Pekka Louko, Guidance for External Events Analysis, SKI Report 02:27, February 2003.