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General Nuclear System Ltd.

UK HPR1000 GDA Project

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Preliminary Safety Report

Chapter 18

External Hazards

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18.1 List of Abbreviations and Acronyms

ALARP	As Low As Reasonably Practicable
DBC	Design Basis Condition
DBE	Design Basis Earthquake
DBF	Design Basis Flood
DEC	Design Extension Condition
FCG Unit 3	Fangchenggang Nuclear Power Plant Unit 3
HPR1000 (FCG3)	Hua-long Pressurized Reactor under Construction at Fangchenggang Nuclear Power Plant Unit 3
HVAC	Heating, Ventilation and Air Conditioning System
IAEA	International Atomic Energy Agency
I&C	Instrumentation and Control
IEC	International Electro-technical Commission
LOOP	Loss of Offsite Power
LUHS	Loss of Ultimate Heat Sink
NNSA	National Nuclear Safety Administration
NRC	Nuclear Regulatory Commission
SAPs	Safety Assessment Principles
SSCs	Structures, Systems and Components
UHS	Ultimate Heat Sink
UK HPR1000	The UK version of the Hua-long Pressurized Reactor
WENRA	Western European Nuclear Regulators Association

18.2 Introduction

An external hazard is an event that originates outside the site and whose effects on the nuclear power plant should be considered. Such events could be of natural or human induced origin and are identified and selected for design purposes during the site evaluation process. According to Reference [1], in some cases events originating on the site but outside the safety related buildings can be treated as external events if the characteristics of the generated loads are similar to those caused by off-site events.

This chapter supports the following high level objective: the design and intended construction and operation of the UK HPR1000 will protect the public by providing multiple levels of defence to fulfil the fundamental safety functions defined in chapter 4 of the PSR:

a) Control of reactivity;

b) Removal of heat from the reactor and from the fuel store;

c) Confinement of radioactive material, shielding against radiation and control of planned radioactive releases, as well as limitation of accidental radioactive releases.

This chapter will demonstrate the following:

a) A design basis external hazard event will not prevent the delivery of the fundamental safety functions;

b) The likelihood and consequence of an off-site release is limited, and the safety assessment will demonstrate that the risk is ALARP;

c) There will be absence of cliff-edge effects just beyond the design basis external hazards.

This chapter is structured as follows:

a) Sub-chapter 18.3 explains the identification process for external hazards in the FCG Unit 3. It also describes the scenarios of combined events;

b) Sub-chapter 18.4 presents the safety philosophy and design principles for protection against each type of external hazard in FCG Unit 3;

c) Sub-chapter 18.5 presents the overall conclusion.

18.3 Identification of External Hazards

18.3.1 Identification of Independent External Hazards

External hazards include natural and man-made hazards, such as earthquake, extreme temperature, external flooding, electromagnetic interference (off-site) and aircraft impact (this list is not exhaustive).

The identification process of independent external hazards in HPR1000 (FCG3) is as

follows:

a) Deriving a comprehensive list based on the regulations and standards

National Nuclear Safety Administration (NNSA) codes and guides as well as International Atomic Energy Agency (IAEA) safety standards and guides have been studied in Reference [2] to [7].

1) NNSA, Safety Regulations for Nuclear Power Plant Siting, HAF 101, 1991;

2) NNSA, Safety Regulations for Design of Nuclear Power Plants, HAF 102, 2004;

3) IAEA, Safety Guide: External Events Excluding Earthquakes in the Design of Nuclear Power Plants, Safety Guide No.NS-G-1.5, 2003;

4) IAEA, Safety Guide: Seismic Design and Qualification for Nuclear Power Plants, Safety Guide No.NS-G-1.6, 2003;

5) IAEA, Safety Guide: External Human Induced Events in Site Evaluation for Nuclear Power Plants, Safety Guide No. NS-G-3.1, 2002;

6) IAEA, Safety Guide: Geotechnical Aspects of Site Evaluation and Foundations for Nuclear Power Plants, Safety Guide No. NS-G-3.6, 2004;

7) IAEA, Specific Safety Guide: Meteorological and Hydrological Hazards in Site Evaluation for Nuclear Installations, Specific Safety Guide No. SSG-18, 2011.

A comprehensive list of external hazards for FCG Unit 3 has been derived taking into account all external hazards described in Appendix A.

b) Adopting relevant good practices and feedback, such as Reference [8].

c) Screening process

The screening process of HPR1000 (FCG3) for external hazards was based on the conditions of the site and its surroundings. The screening criteria are as follows:

1) An event whose frequency is less than once in ten million years is screened out;

2) If the consequence of the event is of low impact and insignificant consequence to the nuclear site, then the event is screened out.

Terrorist or other malicious acts are excluded from this chapter and considered in the sub-chapter 27.3. A comprehensive identification and justification process of external hazards in FCG Unit 3 is given in Appendix A.

18.3.2 Identification of Combined External Hazards

The combined hazards considered include the following scenarios:

a) Consequential Hazards

It refers one or more internal hazards or external hazards as the result of an external

hazard, such as internal flooding or external flooding caused by an earthquake.

An external hazard may also result in a DBC event or a DEC event, such as LOOP or LUHS.

b) Correlated Hazards

It refers some external hazards that occur simultaneously due to a common physical process, for example, a storm may give rise to both rainfall and lightning at the same time.

c) Independent Hazards

It refers that realistic combination of randomly occurring external hazards which have no causal relationship between them, for example, earthquake and environmental air temperatures.

For the site of FCG Unit 3, a set of external hazards have been identified:

a) Earthquakes;

b) External flooding;

c) Extreme low water level;

d) Extreme wind;

e) Tornadoes;

f) Extreme temperature;

g) Lightning;

h) Biological phenomena;

i) Water debris;

j) External explosion;

k) Electromagnetic interference;

l) Aircraft crash.

18.4 External Hazard Analysis

18.4.1 Earthquakes

A seismic event may affect all the components of the plant at the same time. An earthquake, if it is strong enough, has the potential to cause massive disruption and failure of components or buildings on the entire site.

For HPR1000 (FCG3), the design of standard response spectrum adopts the standard response spectrum of NRC RG 1.60 in Reference [9]. The Design Basis Earthquake (DBE) seismic horizontal component and vertical component adopt 0.30g and 0.20g

respectively.

While, according to Reference [10], the seismic level 2 (SL-2) of FCG Unit 3 site corresponds to a level with an annual probability of exceedance of 10^{-4} and its zero period peak accelerations for seismic horizontal and vertical component is 0.16g and 0.11g respectively .

All the SSCs have been designed based on their seismic classification levels, such as Seismic Category 1 (SSE1) and Seismic Category 2 (SSE2). More detailed seismic requirements are described in sub-chapter 4.7.

18.4.2 External Flooding

The external flooding protection maintains equipment important to safety in a dry condition to ensure fundamental safety functions.

According to Reference [11], the Design Basis Flood (DBF) level is usually a result of a combination of different factors such as tides, storm surge, tsunami, and so on. For HPR1000 (FCG3), the DBF level has taken into account of the combination of 10% annual exceedance probability of astronomical tides, probable maximum storm surges and variations of the sea level during the lifetime of nuclear power plant.

Flood scenarios beyond the design basis were considered for HPR1000 (FCG3) after the Fukushima nuclear accident. According to Reference [8], the plant is should be considered the combination the effects of the DBF level and a thousand-year return period rainfall.

The main design measures taken for the HPR1000 (FCG3) against external flooding are as follows:

a) Plant ground elevation;

b) Marine structures, such as levees, sea walls;

c) Plant drainage system;

d) Other protection features (such as watertight doors).

18.4.3 Extreme Low Water Level

Extreme low water level occurs when there is low level of ground water in clay soils or there is insufficient cooling water at the intake for the reactors to function properly. According to Reference [11], intake structures for the heat transferring systems directly associated with the Ultimate Heat Sink (UHS) should be designed to provide an adequate flow of cooling water during credible drought conditions.

For HPR1000 (FCG3), the extreme low water level is a result of the combination of minimum level of astronomical tides and minimum low water level caused by probable maximum storm surge.

18.4.4 Extreme Wind

The design of the nuclear power plant should consider the extreme wind conditions. Missiles such as flying debris and projectiles may be generated in Reference [1]. All of the civil engineering structures which contain equipment important to safety have been designed to resist wind forces.

For HPR1000 (FCG3), the extreme wind data for design is 50m/s for 10min average and 80m/s for 3s gusts of a standard height (10m above ground level).

18.4.5 Tornadoes

The SSCs important to safety have been protected against tornado wind forces and generated missiles.

The frequency of design basis tornado characteristics of HPR1000 (FCG3) corresponds to the level with an annual probability of exceedance of 10^{-7}. However, the tornado characteristics of geographical region II in NRC RG 1.76 in Reference [12], have been used for HPR1000 (FCG3) as an envelope design.

18.4.6 Extreme Temperature

This hazard covers issues around low and high temperatures for water and air.

According to Reference [1], items important to safety have been protected against extreme temperatures, especially for items that are sensitive to extreme temperatures, such as Heating, Ventilation and Air Conditioning System (HVAC), Instrumentation and Control (I&C) equipment.

At the design basis extreme temperatures, it is necessary to ensure that items important to safety perform their functions. For HPR1000 (FCG3), the extreme high and low air temperatures used for the safety HVAC design are 36.1℃(dry)/30.3℃(wet) and 3.7℃(dry)/ 3.2℃(wet), the extreme high and low water temperatures used for the safety design of UHS systems are 38℃and 8.9℃. More temperature parameters are described in sub-chapter 3.2.

18.4.7 Lightning

Lightning hazard mainly affects electrical equipment, and may lead to fire, spurious electrical signals and explosion of transformers. Items important to safety have been protected from lightning.

For HPR1000 (FCG3), the protection design of lighting complies with the technical guideline in Reference [13]. Protection equipment is provided to divert lightning discharges away from vulnerable parts of sensitive structures and to carry current to the ground. Surge protection is provided for systems to stop currents giving rise to unacceptable potential differences or electromagnetic interference. Steel framed buildings have been adequately earthed and can be considered to be a Faraday cage.

18.4.8 Biological Phenomena

Biological phenomena mainly affect the availability of the cooling chain or the function of ventilation systems. According to Reference [1], very often malfunctions have also been recorded in ventilation systems because of clogging by leaves, birds or insects in the filters. In some cases, I&C cables may be attacked by rats and bacteria.

Items important to safety are protected from biological hazards in HPR1000 (FCG3). For the water intakes of UHS, some measures have been taken to prevent against excessive growth of algae, mussels or clams, exceptional large quantities of fish, or jellyfish, such as using a disinfection system, installing filter features, checking and cleaning the filter regularly. The detriment caused by biological hazard is slow-developing and administrative actions will be taken to ensure that safety systems are not compromised.

18.4.9 Water Debris

Water intakes and UHS structures may be damaged by ship collision, ice or floating debris (log jam, flotsam, jetsam, sedimentation or siltation). Also a ship collision event could generate oil spills, which could affect the availability or quality of cooling water. There is overlap between this group of hazards, industrial hazards and biological phenomena in determining the hazard and its protection.

For HPR1000 (FCG3), the sea routes and shipping density around the nuclear power plant have been investigated to identify the probability of damage to the intake and outfall according to Reference [1] and [5]. However the main protection measure is to keep the water intake structures integrity. Site specific measures can be taken such as adapting the layout and protective barriers. Other features include installing interception grids and using coarse mesh in front of the intake pipe. Regular inspections will be carried out to ensure no accumulation of sedimentation, siltation or other debris.

18.4.10 External Explosion

External explosion caused by industrial facilities/storage and transport routes, may directly or indirectly result in the risk of a radiological release. Items important to safety should be protected against external explosion.

For HPR1000 (FCG3), standard load-time function derived from pressure wave resulting from external explosion has been used as a design basis load according to Reference [5]. It is a triangular pressure wave with a tight wave front, reaching a maximum overpressure of 10kPa and duration of 300ms. Items important to safety are protected against external explosion waves although there are no exploder sources off-site.

18.4.11 Electromagnetic Interference

Electromagnetic interference can affect the functionality of items important to safety. According to Reference [1], it can be initiated by both on-site (high voltage switchgear, portable telephones, portable electronic devices or computers) and off-site sources (radio interference or the telephone network), and also natural phenomena (electromagnetic

pulse by lightning).

For HPR1000 (FCG3), all equipment important to safety which are sensitive to electromagnetic interference have been protected to withstand the electromagnetic environment. Special measures have been taken in the design of the nuclear power plant, such as appropriate cable shielding.

18.4.12 Aircraft Crash

For HPR1000 (FCG3), the following two types of aircraft crash scenarios have been considered:

a) Impact of light aircraft;

b) Impact of large commercial aircraft.

Measures such as structural design, redundancy design and geometric separation have been taken to ensure the availability of devices for reactor shutdown and maintaining safe shutdown state, and prevent the effects from unacceptable radioactive release in case of aircraft crashes according to Reference [1].

For HPR1000 (FCG3), all of the civil structures that contain equipment important to safety are designed to resist the impact loads of light aircraft. Certain structures of buildings including reactor building, fuel building and safeguard building C have already been designed to resist large commercial aircraft impact loads. The effects of vibrations, fire and explosion hazards deriving from aircraft crash will be analysed.

18.4.13 Administrative Measures

The design for a nuclear power plant ensures that the plant and items important to safety have the appropriate characteristics to perform with the necessary reliability. In addition, the administrative measures are specified to mitigate the consequence of external events in HPR1000 (FCG3), such as:

a) Availability of long term weather forecasting , storm forecasting and a way to obtain this data;

b) Availability of measures to prevent flooding water access into buildings(e.g. sandbags and stop logs);

c) Availability of emergency facilities to repair damaged systems following a severe external hazard;

d) Availability of staff and workers that can be called upon in response to bad weather warnings to complete any necessary hazard mitigation actions, before the weather deteriorates to a level where workers' safety is challenged;

e) Protection emergency control centers, access points and associated equipment against external hazards.

18.5 Conclusion

The external hazards identification and screening process in HPR1000 (FCG3) was not only in compliance with the related standards and regulations, but also suitable to the FCG Unit 3 site conditions. The protection design and safety analysis for the HPR1000 (FCG3) have shown that the external hazards do not compromise the fundamental safety functions.

However, some gaps between HPR1000 (FCG3) and UK requirements, which are UK context related, have been identified, such as:

a) The external hazard list needs to be extended to include more hazards according to UK context (e.g. snow) and relevant good practice (e.g. WENRA , Reference [14]);

b) The frequencies of annual exceedance for natural and man-made external hazards need to be specified according to SAPs in Reference [15];

c) Beyond design basis external hazards need to be considered as per SAPs;

d) Climate change will be considered in climatic external hazards according to Reference [16].

The gaps will be closed through GDA process.

18.6 References

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

[2] NNSA, Safety Regulations for Nuclear Power Plant Siting, HAF 101, 1991.

[3] NNSA, Safety Regulations for Design of Nuclear Power Plants, HAF 102, 2004.

[4] IAEA, Safety Guide: Seismic Design and Qualification for Nuclear Power Plants, Safety Guide No.NS-G-1.6, 2003.

[5] IAEA, Safety Guide: External Human Induced Events in Site Evaluation for Nuclear Power Plants, Safety Guide No. NS-G-3.1, 2002.

[6] IAEA, Safety Guide: Geotechnical Aspects of Site Evaluation and Foundations for Nuclear Power Plants, Safety Guide No. NS-G-3.6, 2004.

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

[8] NNSA, General Technical Requirements for Post-Fukushima-Accident Improvement Actions of Nuclear Power Plants, 2012.

[9] NRC, Design response spectra for seismic design of nuclear power plants, RG 1.60, Revision 2, 2014.

[10] IAEA, Safety Guide: Evaluation of Seismic Hazards for Nuclear Power Plants,

Safety Guide No. NS-G-3.3, 2002.

[11] IAEA, Safety Guide: Flood Hazard for Nuclear Power Plants on Coastal and River Sites, Safety Guide No. NS-G-3.5, 2003.

[12] NRC, Design-basis tornado and tornado missiles for nuclear power plants, RG 1.76, Revision 1, 2007.

[13] IEC, Protection Against Lightning, IEC 62305, 2010 edition, 2010.

[14] WENRA, Safety Reference Levels for Existing Reactors, September 2014.

[15] ONR, Safety Assessment Principles for Nuclear Facilities, Revision 0, November 2014.

[16] ONR, Nuclear Safety Technical Assessment Guide, External Hazards, NS-TAST-GD-013, Revision 5, September 2014.

Appendix A

Identification and Justification of External Hazards in FCG Unit 3

The external hazards are identified from the following references.

[1] NNSA, Safety Regulations for Nuclear Power Plant Siting, HAF 101, 1991.

[2] NNSA, Safety Regulations for Design of Nuclear Power Plants, HAF 102, 2004.

[3] IAEA, Safety Guide: Seismic Design and Qualification for Nuclear Power Plants, Safety Guide No. NS-G-1.6, 2003.

[4] IAEA, Safety Guide: Geotechnical Aspects of Site Evaluation and Foundations for Nuclear Power Plants, Safety Guide No. NS-G-3.6, 2004.

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

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

[7] IAEA, Safety Guide: External Human Induced Events in Site Evaluation for Nuclear Power Plants, Safety Guide No. NS-G-3.1, 2002.

T-appendix A-1 Identification and justification of external hazards in FCG Unit 3

Hazard	**NNSA codes and guides**	**IAEA safety standards and guides**	**FCG Unit 3**
Earthquakes	---		Identified as an external hazard
- Ground motion	[1] Sec 4.7 [2] Sec 5.2.5.2	[3] Sec 1.7	√
- Liquefaction	[1] Sec 4.8	[3] Sec 1.4	√
- Dynamic compaction and settlement	[1] Sec 4.7	[3] Sec 5.24 [4] Sec 4.43	√
- Surface faulting	[1] Sec 4.4	[4] Sec 2.6	√

Hazard	NNSA codes and guides	IAEA safety standards and guides	FCG Unit 3
External flooding	---		Identified as an external hazard
- Storm surges	[1] Sec 4.1, 4.2, 4.3 and 4.14	[5] Sec 1.9	√
		[6] Sec 2.11	√
- Seiches		[5] Sec 10.1	√
		[6] Sec 2.11	
- Tsunamis		[5] Sec 1.9	√
		[6] Sec 2.11	
- Landslides and avalanches into water		[5] Sec 1.9	√
		[6] Sec 2.12	
- Rainfall		[5] Sec 1.9	√
		[6] Sec 2.6	
		[6] Sec 2.11	
- Wind waves		[5] Sec 10.1	√
		[6] Sec 2.11	
- Sea level (tides and anomalies)		[5] Sec 1.9	√
- River levels		[5] Sec 10.1	Excluded by specific site character.
		[6] Sec 2.12	
- Dam forming		[5] Sec 1.9	
- Dam failure		[5] Sec 1.9	
		[6] Sec 2.11	
- Snow melt		[5] Sec 1.9	
- Ground water level		[6] Sec 2.12	√

Hazard	NNSA codes and guides	IAEA safety standards and guides	FCG Unit 3
Low water level	---		Identified as an external hazard
- Low water level (It is related to some the flooding initiating events i.e. storm surges, seiches, tsunamis, underwater ground collapse, sea level, wind waves, river levels, landslides and avalanches into water, dam forming upstream, watercourse containment failure etc.)	[1] Sec 4.14	[6] Sec 2.11	√
Extreme wind and tornadoes	---		Identified as an external hazard
- High wind including cyclones and hurricanes	[1] Sec 4.10 [2] Sec 5.2.5.2	[5] Sec 1.9 [6] Sec 2.6	√
- Tornadoes	[1] Sec 4.9 [2] Sec 5.2.5.2	[6] Sec 2.7	√
- Tornado and wind-blown missiles	[1] Sec 4.9	[6] Sec 4.52	√
- Waterspouts	---	[5] Sec 11.1 [6] Sec 2.7	Excluded by specific site character.
- Sand and dust storms	[1] Sec 4.11	[5] Sec 11.2 [6] Sec 2.8	Excluded by specific site character.
- Salt spray	---	[5] Sec 11.2	√
Extreme metrological conditions	---		Identified as an external hazard

Hazard	NNSA codes and guides	IAEA safety standards and guides	FCG Unit 3
- High air temperature	[1] Sec 4.14	[5] Sec 1.9	√
	[2] Sec 5.2.5.2	[6] Sec 2.6	
- Low air temperature	[1] Sec 4.14	[5] Sec 1.9	√
	[2] Sec 5.2.5.2	[6] Sec 2.6	
- High ground temperature	[1] Sec 4.11	[5] Sec 1.9	Excluded by specific site character.
- Low ground temperature	[1] Sec 4.11	[5] Sec 1.9	Excluded by specific site character.
- Frozen earth / permafrost	[1] Sec 4.11	[5] Sec 1.9	Excluded by specific site character.
		[4] Sec 2.6	
- High water temperature	[1] Sec 4.11	[5] Sec 1.9	√
- Low water temperature	[1] Sec 4.11	[5] Sec 1.9	√
- Humidity	[1] Sec 4.11	[5] Sec 12.1	√
- Air pressure	[1] Sec 4.11	[6] Sec 3.11	√
- Snow and flake ice	[1] Sec 4.11	[5] Sec 1.9	Excluded by specific site character.
		[6] Sec 2.6	
- Hail / sleet	[1] Sec 4.11	[5] Sec 1.9	Excluded by specific site character.
		[6] Sec 2.8	
- Fog / mist	---	[6] Sec 9.9	Excluded by specific site character.
- Frost	[1] Sec 4.11	[5] Sec 1.9	Excluded by specific site character.
		[6] Sec 2.8	
- Drought	[1] Sec 4.14	[5] Sec 1.9	√
- Surface icing / frazil ice	[1] Sec 4.14	[5] Sec 12.1	Excluded by specific site character.
		[6] Sec 2.8	
		[6] Sec 2.12	
- Ice barrier / pack / ice flows	[1] Sec 4.14	[5] Sec 12.1	Excluded by specific site character.

Hazard	NNSA codes and guides	IAEA safety standards and guides	FCG Unit 3
Electromagnetic interference	---		Identified as an external hazard
- Electromagnetic pulse	[1] Sec 4.15	[5] Sec 9	√
- External EMI	[1] Sec 4.15	[5] Sec 1.9 [6] Sec 2.7	√
Lightning	---		Identified as an external hazard
- Electromagnetic interference	[1] Sec 4.11	[5] Sec 1.9 [6] Sec 2.7	√
- Electrical discharge	[1] Sec 4.11	[6] Sec 4.33	√
Biological phenomena	---		Identified as an external hazard
- Marine organism event	[1] Sec 4.14	[5] Sec 13.7	√
- Algae		[5] Sec 13.1	√
- Sea weed		[5] Sec 13.7	
- Fish		[5] Sec 13.1	
- Jellyfish		[5] Sec 13.1	
- Marine growth (mussels, clams, etc.)		[5] Sec 13.1	
- Infestation		[5] Sec 13.1	√
- Leaves		[5] Sec 13.1	√
- Airborne swarms		[5] Sec 13.1	√
- Terrestrial animals		[5] Sec 13.1	√
- Birds		[5] Sec 13.1	√
- Bacteria		[5] Sec 13.1	√
Water debris	---		Identified as an external hazard
- Flotsam / jetsam	[1] Sec 4.14	[5] Sec 1.9	√

Hazard	NNSA codes and guides	IAEA safety standards and guides	FCG Unit 3
- Log jam	[1] Sec 4.14	[5] Sec 1.9	√
- Sedimentation and siltation caused by strong water currents	[1] Sec 4.14	[5] Sec 1.9	√
- Strong water currents			
Volcanoes	---		Excluded by specific site character.
-projectiles	[2] Sec 5.2.5.2	[5] Sec 14.3	---
- ash			
- lava flows			
- snow melt			
- shock			
- lightning			
- gases			
- earthquakes			
- ground deformation			
- tsunamis			
- groundwater			
Extra-terrestrial	---		Excluded by specific site character.
- Space debris	---	---	---
- Meteorite	---	---	---
Industrial hazards	---		Identified as an external hazard
- External missiles	[1] Sec 4.13 and 4.15	[7] Table I	√
- External fire (including natural)		[5] Sec 1.9	√
		[7] Table I	
- Pollutants released from		[7] Table I	√

Hazard	NNSA codes and guides	IAEA safety standards and guides	FCG Unit 3
marine accident	[1] Sec 4.13 and 4.15		
- Transport (road, sea, rail)		[7] Table I	√
- Explosions (blast, fragments and vibrations)		[5] Sec 1.9	√
		[7] Table I	
- Liquid release (toxic, flammable, radioactive)		[7] Table I	√
- Gas release (toxic, asphyxiating, flammable)		[5] Sec 1.9	√
		[7] Table I	
- Radioactive materials		[5] Sec 1.9	√
		[7] Table I	
- Pipelines and tanks (gas, oil, water)		[7] Table I	√
		[6] Sec 2.12	
- Excavation work and ground collapse		[7] Table I	Excluded by specific site character.
- Mining (inactive and active)		[4] Sec 2.6	Excluded by specific site character.
- Electromagnetic interference / pulse		[5] Sec 1.9	√
		[7] Table I	√
- Eddy currents into the ground		[7] Table I	√
Aircraft crash	---		Identified as an external hazard
- Missile penetration and global damage	[1] Sec 4.12	[5] Sec 4.8	√
- Fire and explosion			
- Vibration			

Note: '√' means the hazard is considered in FCG Unit 3.