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SUB-CHAPTER 2.1 – SITE DATA USED IN THE SAFETY ANALYSES

The objective of this sub-chapter is to present a summary of the site data used in the safety analysis presented in the Pre-Construction Safety Report.

These data are considered to be typical of UK coastal sites in England and Wales on which nuclear power stations have been sited. The data relate to:

- The essential external supporting systems: the heat sink and the power supply (grid connections).
- The external hazards Probabilistic Safety Analysis (PSA), which considers the risk due to hazard conditions exceeding design values.
- The site data used for the Level 3 PSA in evaluation of the radiological consequences of accidents

The data do not cover all the site data that would be used in a site specific safety analysis.

In some instances, reference is made to EUR requirements [Ref-1].

1. HEAT SINK

The EUR generic requirements [Ref-1] specify minimum and maximum cooling water temperatures for new-build LWRs:

- The maximum temperature, in all cases, is 30°C.
- The minimum temperature is -0.5°C for seawater cooling and 0°C where cooling is derived from rivers or cooling towers. Cooling water quantities are not defined since this will depend on the specific reactor design.

The maximum intake water temperature for the design of UK EPR is 26°C. The minimum value is taken from the EUR specification.

This maximum value is consistent with the EUR generic requirements and is also expected to be bounding for potential UK EPR sites**.**

A second extreme temperature is assumed in the Design Basis Analysis (categories PCC-2, 3 and 4) and is equal to 30°C.

The maximum cooling water mass flow requirement for a single EPR unit is approximately 67 m^3/s. This requirement can be met at most of the UK sites where an EPR would be likely to be sited. However in some cases, where direct sea access is compromised by unfavourable sea bed profiles, or where cooling water is abstracted from estuarial water, cooling towers may be required to supplement the seawater cooling. Any supplementation of reactor cooling by use of cooling towers would be addressed in a site specific safety submission, and is outside the scope of GDA.

The risk of loss of heat sink due to a massive influx of marine organisms leading to a potential water intake clogging is discussed in section 5 in this sub-chapter.

2. GRID CONNECTIONS

EUR generic requirements [Ref-1] call for a 400 kV circuit and a rated frequency of 50 Hz. The grid minimum short circuit capability at the substation should be no less than 7 GVA, and the maximum should be no greater than 44 GVA. There are no requirements regarding power-carrying capacity, since this will depend both on the size of plant proposed and the existing power sources on the network.

The EPR unit is connected to the external network via a main connection and an auxiliary connection. Accidental grid disconnection has safety implications and is considered as a PCC-2 or PCC-3 event depending on the duration of the transient (Chapter 14).

Some potential UK sites meet the 400 kV connection requirement, but may not all meet the UK Security and Quality of Supply Standard (SQSS). For sites where an adequate 400 kV connection is not available, some reinforcement of existing circuits or installation of new circuits would be likely to be needed if the site was selected for an EPR.

The requirement for a 400 kV dual connection must be met at any site where an EPR is to be constructed, if necessary by upgrading existing lower voltage lines or by new construction.

In the Probabilistic Safety Assessment in Chapter 15 of the PCSR, the following frequencies of Loss Of Off-site Power (LOOP), accounting for external hazards, are taken from the EUR [Ref-1]:

- Short term LOOP, less than 2 hours: failure frequency = 6.10^{-2} /r-yr
- Long term LOOP, more than 2 hours: failure frequency = 10^{-3} /r-yr

In addition, a probability value of 10^{-3} per demand is assumed for the induced-LOOP conditional probability in the case of unplanned reactor trip.

These values are considered to be appropriate in the frame of a generic assessment for an EPR connected to the UK grid. However, the sensitivity to these values is studied in the Probabilistic Safety Assessment (Chapter 15) assuming cases with lower reliabilities.

3. DENSITY AND DISTRIBUTION OF LOCAL POPULATION

The level 3 PSA is the only application in the PCSR which uses demographic data, even though the data are only used implicitly, as they are fully embedded in the applied approach outlined below.

A twofold approach is used:

- Firstly, major accident screening rules are set up. They are expressed as fractions of the core inventory above which consequences are foreseen to be significant in terms of societal risk (comparison to the Safety Assessment Principles (SAPs) Numerical Target 9).

- Secondly, the screening rules are benchmarked against existing UK site specific Level 3 PSA studies to confirm the thresholds have been set at an appropriate level. For this comparison, the base case is taken as the most onerous, in terms of numbers of statistical fatalities. Of the UK sites presented in the Safety Review Guide for the Gas Cooled Reactors [Ref-1], the most onerous is found to be Hinkley Point. The method developed in the supporting study shows how the results from AGR/Magnox evaluations can be used to carry out this comparison, namely using an "equivalent consequence" scale (Sub-chapter 15.5).

For the assessment of dose to an individual off-site for the Design Basis Analysis and for comparison with SAPs Numerical Target 8, no credit is taken for any countermeasures implemented to protect the local population.

4. MAN-MADE EXTERNAL HAZARDS

4.1. ACCIDENTAL AIRCRAFT CRASH

In the UK, the airspace from ground level to approximately 66,000 ft is characterised, in broad terms as either Controlled Airspace (CAS) or Uncontrolled Airspace (UCAS) [Ref-1]. Commercial, passenger-carrying aircraft operate almost exclusively in CAS, while most military, instructional or recreational flying takes place in UCAS. There are also prohibited, restricted and danger areas, which include the airspace immediately around nuclear facilities. CAS is divided into five main types, those of particular relevance being the Airways corridors that form the main routes connecting major airports, which have a minimum height of 5000 ft (1500 m), and the Upper Airspace, which comprises the majority of UK airspace above 24,500 ft (7500 m). Within CAS, all traffic is known to the Air Traffic Control system.

In general, the restricted zone around UK nuclear power stations is a circle of radius 2.0 nautical miles (3.7 km) and an altitude of 2000 ft (610 m), with exceptions being made for helicopters having permission to land at the station. Commercial aircraft would be expected to be flying considerably higher than this, under instructions from Air Traffic Control.

The restricted zone over most of the potential UK sites is already in accordance with, or in excess of, the requirements for a restricted zone around UK nuclear power stations. For one potential site, the altitude of the restricted zone is reduced to 1500 ft to enable an instrument approach procedure at a nearby airport.

Chapter 15 describes an analysis for Accidental Aircraft Crash. The generic site is supposed to be located at least 40 km from any high crash concentration zone determined for Military Combat Aircraft. Thus the generic crash rates applied in the Accidental Aircraft Crash PSA are the following [Ref-2]:

- Light Aircraft: $2.46\ 10^{-5}\ km^{-2}y^{-1}$
- Helicopters: $1.16\ 10^{-5}\ km^{-2}y^{-1}$
- Small transport: $0.12\ 10^{-5}\ km^{-2}y^{-1}$
- Large transport: $0.22\ 10^{-5}\ km^{-2}y^{-1}$
- Military: $0.46\ 10^{-5}\ km^{-2}y^{-1}$

4.2. INDUSTRIAL ENVIRONMENT AND TRANSPORTATION ROUTES

4.2.1. Explosions

The generic UK site is considered to be characterised by a negligible frequency (< 10^{-5}) of an external explosion exceeding the design basis explosion pressure wave. The latter is defined as an incident triangular pressure wave with a peak pressure of 10 kPa and having a duration of 300 ms.

4.2.2. Fires

The generic UK site and its surroundings are assumed to be characterised by land uses such that there is no risk of external fire propagation which could threaten plant safety.

4.2.3. Chemical releases

It is assumed that there would be no hazardous industry within a radius of 10 km around the reactor.

The frequency of road or maritime accident which would threaten the plant safety by drift of a chemical release is assumed to be lower than 10^{-5}/r.

4.2.4. Electro-magnetic interference

It is considered that there is no large source of electro-magnetic interference in the vicinity of the generic UK site.

4.2.5. Missiles from other plants on-site

It is considered that the generic UK site may accommodate other industrial installations, but that the EPR arrangement on the site will be such that any risk of missiles from these installations, with a potential to threaten safety, will be negligible.

4.2.6. Release of Oil or other materials from ships

For the generic UK site, the frequency of occurrence of a release from a ship that could initiate clogging of the water intakes is considered negligible compared to the frequency of water intake clogging by marine organisms (see section 5 in this sub-chapter).

4.2.7. Direct impact from ship collision

For the generic UK site the probability of direct impact from ship collision is assumed to be negligible (<<10^{-5}).

4.3. MALICIOUS ACTIVITY

Malicious activity (in the form of sabotage) is identified in the EUR generic requirements [Ref-1] as one of the hazards that should be considered for a future European LWR, although the outcome of such studies would not be published for security reasons. The EUR requirements also identify intentional aircraft crash as a hazard that must be considered in the design. Protection is to be based on a probabilistic approach unless the authorities require a deterministic approach. Standard LWR designs may or may not include aircraft crash protection but, for those that do not explicitly include it, the design must ensure protection against light or military aircraft for all sensitive parts of the plant. An aircraft crash may be malicious (as was the case for the destruction of the World Trade Centre in 2001). Malicious aircraft crash is addressed in the UK EPR design, as described in Sub-chapter 13.1, section 3.

In the UK, it is the responsibility of the Office for Civil Nuclear Security (OCNS) to define worst-case scenarios for malicious activity. The OCNS establishes a Design Basis Threat (DBT), which defines the hostile activities that could be faced by a civil nuclear facility, and its required capability to withstand such a threat. The DBT is regularly reviewed, to ensure that it remains up-to-date. Details of the DBT cannot be published since it is security classified. Information justifying that the EPR design adequately addresses the DBT will be discussed directly with OCNS.

5. NATURAL EXTERNAL HAZARDS

5.1. SEISMOTECTONIC

The UK generic site is assumed to have a seismic activity and soil properties covered by the Design Basis Earthquake (DBE) and associated standard ground conditions (see Chapter 13). In the PCSR, a Seismic Margin Assessment is used to provide a seismic safety analysis (see Chapter 15).

5.2. EXTREME WEATHER CONDITIONS

Except where otherwise stated meteorological data given in this section are taken from [Ref-1] Met Office data (website).

5.2.1. Strong winds

Wind speed data (highest gust speed, mean wind speed) have been collected from UK Met Office data for the period 1968 to 2002. The highest gust speed recorded in UK in that period at a low-level site is 123 knots (63 m/s), which occurred at Fraserburgh, Aberdeenshire on February 1989.

The EPR design wind speed will be selected depending on the specific site chosen and will be based on the 1 in 10,000 year level as required by UK licensing safety principles (SAPs) [Ref-1], with inclusion of an adequate safety margin.

The probabilistic analysis of hazard events presented in Chapter 15 of the PCSR discounts the risk contribution due to high wind as the EPR is designed to withstand extreme wind conditions with a substantial safety margin.

5.2.2. Tornadoes

The following data are available from the TORRO organisation [Ref-1].

On average, 33 tornadoes are reported each year in the United Kingdom. This average is based on a 30 year period, though in reality yearly figures may vary dramatically.

Most tornado reports are from the Western Midlands, Eastern Midlands, Central-Southern England, South-Eastern England and East Anglia. Some occur in South-Western England, North-Western England, North-Eastern England and Wales. Tornadoes are rare in Northern Ireland and Scotland.

For the generic UK site, it is assumed that an average of 33 tornadoes per year occur over a land area of 150,000 square kilometres which corresponds approximately to the area of England and Wales. On average it is supposed that a tornado is of 50m width and that it travels for 3 km. This gives an approximate frequency of a structure being struck by a tornado in England and Wales as 3.3×10^{-5} /y.

5.2.3. High air temperatures

The highest temperature recorded in UK is 38.5°C, measured at Brogdale near Faversham, 10 August 2003.

Over England, the mean annual temperature at low altitudes varies from about 8.5°C to 11°C, with the highest values occurring around or near to the coasts of Cornwall. The mean annual temperature decreases by approximately 0.5°C for each 100m increase in height so that, for example, Great Dun Fell in Cumbria (at 857 m) has an annual mean temperature of about 4°C.

Over Wales, the mean annual temperature at low altitudes varies from about 9.5°C to 10.5°C, with the higher values occurring around or near to the coasts. The mean annual temperature decreases by approximately 0.5 °C for each 100 m increase in height so that, for example, Bwlchgwyn in Clwyd (at 386 m) has an annual mean temperature of 7.3°C. On this basis, Snowdon (at 1,085 m) would have an annual mean temperature of about 5°C.

July is normally the warmest month in Wales, and the highest temperatures of all have occurred furthest away from the cooling influence of the Atlantic. The highest temperature ever recorded in Wales is 35.2°C at Hawarden Bridge in Clwyd, on 2 August 1990.

For the generic UK coastal site it is considered that the frequency of exceeding a 12 hour average temperature of 36°C, or an instantaneous temperature of 42°C, accounting for climate change, will be lower than 10^{-4}/y.

5.2.4. Low air temperatures

The minimum temperature recorded in the UK was -27.2ºC, measured on 10 February 1982 (Braemar) and 30 December 1995 (Highland).

To a very large extent, winter temperatures in the British Isles are influenced by the surface temperatures of the surrounding sea, which reach their lowest values in late February or early March. Around the coasts February is thus normally the coldest month, but inland there is little difference between January and February.

The coldest nights are those on which there is little wind, skies are clear, and there is a covering of snow on the ground; the lowest temperatures tend to occur away from the moderating influence of the sea, on the floors of inland valleys into which the cold air drains. It was under such conditions that the temperature fell to -26.1°C, the lowest ever recorded in England and Wales, at Newport in Shropshire, on 10 January 1982. Coastal areas tend not experience such cold nights as inland areas.

For the generic UK coastal site it is considered that the frequency of experiencing a temperature below -15°C for more than 7 days, a temperature of -25°C for between 6 hours and 7 days or a temperature of -35°C for less than 6 hours, accounting for climate change, is below 10^{-5}/yr.

5.2.5. Frazil ice

Frazil ice may form in case of strong wind in conjunction with below zero temperature and open water. Under these conditions the water temperature may be around 0°C. Ice crystals are formed in the water and carried by turbulence to depths of several meters below the surface, or in case of half-gale down to a depth of 10 meters. The crystals may form lumps and may stick to below-water structures. In this way, a thick ice coating may form on the intake strainers. There is a risk of frazil ice in the interval -0.5°C to -1.0°C.

The frequency of loss of heat sink water due to frazil ice is considered to be negligible compared to the frequency of loss of heat sink due to biological fouling (see section 5 in this subchapter).

5.2.6. Freezing rain

Freezing rain is considered as a potential cause of failure of the grid supplies. The assumed frequency of loss off-site power (LOOP) in the Chapter 15 Probabilistic Safety Assessment contains an allowance for grid failure due to climactic factors such as freezing rain.

5.2.7. Extreme rainfall

The EPR design addresses extreme rainfall via the protection provided against external flooding (see below) which is site specific. Extreme rainfall is not considered within the context of GDA.

5.2.8. Extreme snowfall

The following event information was provided by the UK Met Office.

Snow is comparatively rare near sea level in England, but much more frequent over hills. The average number of days each year when sleet or snow falls in England varies from about 10 or less in some south-western coastal areas to over 50 in the Pennines. Snow rarely lies on the ground at sea level before December or after March, and the average annual number of days with snow lying in England varies from five or less around the coasts to over 90 in parts of the Pennines. A day of snow lying is defined as one with snow covering at least half of the ground at 0900 UTC (Co-ordinated Universal Time).

The number of days of snowfall and snow cover varies enormously from year to year. At many places in the last fifty years it has ranged from none at all in a number of winters to in excess of 30 days during the winters of 1946/47 and 1962/63. Even places near the coast experienced prolonged snow cover during these two winters.

In heavy snowfalls there can be extensive drifting of the snow in strong winds, especially over the higher ground, resulting in severe dislocation of transport. Fortunately such occasions are rare, but one of the worst snowstorms this century in South Wales occurred on 7 and 8 January 1982, when depths of one meter or more were commonplace, with severe drifting and power lines brought down.

Snow is comparatively rare near sea level in Wales, but much more frequent over the hills. The average number of days each year when sleet or snow falls in Wales varies from about 10 or less in some south-western coastal areas to over 40 in Snowdonia. Snow rarely lies on the ground at sea level before December or after March, and the average number of days with snow lying in Wales varies from six or less around the coasts to over 30 in Snowdonia.

Based on this information, it is assumed in the Chapter 15 Probabilistic Safety Analysis that the frequency of combined high snow and strong wind, which would have the potential to block the air intakes of the diesel generators, is 1 in 10 years.

5.2.9. External flooding

The design of the platform height will be set such that the frequency of water height exceeding the platform level would be lower than 10^{-5} /year accounting for combinations of events such as an extreme high water table coinciding with extreme rainfall. The unit design will include an adequate margin to provide protection against external flooding events beyond the design basis.

The probabilistic analysis of hazard events presented in Chapter 15 of the PCSR discounts the risk contribution due to external flooding as the EPR is designed to withstand extreme flooding events with a substantial safety margin.

As design against external flooding is specific to the EPR site, it is not considered further in the GDA.

5.3. BIOLOGICAL HAZARDS

5.3.1. Biological fouling/clogging

The issue is the potential for cooling water intakes to become completely or partially blocked by seaweed, fish, jellyfish, algae other marine growth.

The frequency of massive influx of marine organisms which could potentially lead to the clogging of the water intakes is assumed to be 1 per year. In order to prevent total clogging of the cooling water intake from in the case of a massive influx of marine organisms, a preventive trip of the conventional service water pumps is made.

5.3.2. Animal infestation

EUR generic requirements [Ref-1] identify infestation as a natural hazard that requires consideration, listing two particular issues:

- blockage by insects of air intakes to Heating, Ventilating and Air Conditioning (HVAC), diesel generators or other systems that rely on an air supply to maintain their function,

- loss of electrical equipment by, for instance, shorting as a result of gnawing and destruction of insulation materials by rodents.

These risks are not taken into account in the context of the GDA but will be considered in site specific safety submissions.

6. SITE DATA USED IN ASSESSMENT OF RADIOLOGICAL CONSEQUENCES OF ACCIDENTS

6.1. GENERAL PRINCIPLES

The preliminary dose calculations, which are based on EDF methodology, are considered to be generic in nature.

The assessment of the effective dose takes into account the four exposure routes from an atmospheric release: direct radiation from the plume, direct radiation from deposited activity, inhalation and ingestion. Off-site emergency procedures and foodstuff restrictions are not taken into account in the evaluations.

In general, dose calculation results are normally presented for two hypothetical most exposed persons: an adult and a 1-year-old infant at the site boundary (500 m) over 7 days, and an adult at a distance of 2 km from the point of release over 50 years.

In the radiological consequences analysis presented in the PCSR, results are presented as follows:

- At 7 days: the doses at 7 days correspond to the exposure of an individual located in the immediate vicinity of the site at the time of the release. The effective doses received via inhalation and external exposure to the plume and to deposits on the ground are calculated at 500 m from the reactor. In addition, the thyroid dose, due essentially to radio-iodine inhalation, is evaluated for an adult and a 1-year-old infant at the same distance;

- At 50 years: the 50 year dose represents the effects integrated over the life of an individual. In addition to the dose received during the passage of a radioactive cloud, the dose received during this period is that due to the persistence of the contamination deposited on the ground. Individuals living close to the power plant are subjected to external exposure to deposits on the ground and to internal exposure by ingesting contaminated foodstuffs, over a duration of 50 years. These doses are evaluated 2 km from the point of release.

6.2. GENERIC SITE DATA

Generic site data are used to assess doses for the two groups of population described above.

The relevant data are listed below.

Atmospheric conditions:

The atmospheric conditions impact the dispersion of the fission products released to the environment.

The atmospheric concentration, integrated over the passage of the plume, is obtained using differential equations governing atmospheric diffusion. The model used is a Gaussian plume model (see Sub-chapter 14.6). The releases are conservatively assumed to occur at ground level. Terrain features are not taken into account.

The calculations are performed taking into account a range of standard meteorological conditions which ensure a broad coverage of potential dispersion conditions. To give a conservative assessment the Gaussian plume model is applied with standard deviations for the class 2 conditions in the Doury model (DF2), which represent a condition of weak dispersion with a wind of 2 m/s.

Changes in meteorological conditions such as wind speed, wind direction and diffusion are taken into account according to the release duration with a correction factor, ranging from 1 to 5, applied to the horizontal standard deviation.

These conditions are expected to cover the conditions at UK sites to a large extent.

Habit data of local/Resident family Exposure Group:

As regards life habits such as food consumption rates and exposure conditions, the values used in the EDF methodology (see Sub-chapter 14.6) are realistic for French sites. The data used are shown in Sub-Chapter 2.1 - Tables 1 to 3 below.

The food consumption data are used only for the 50-year dose calculation. The associated values may be different from UK average data. However, even for the reference severe accident, the overall margin between the actual results and the acceptable individual dose intake over 50 years is so large that the habit differences between French and UK populations can be discounted in the context of Generic Design Assessment.

SUB-CHAPTER 2.1 - TABLE 1

Food consumption

Foodstuff	Adult (kg/d)	Infant (1 year old) (kg/d)
Cow milk	0.094	0.000
Tinned milk	0.180	0.410
Butter	0.018	0.009
Cheese	0.039	0.012
Cereal flour	0.200	0.045
Beef	0.053	0.018
Chicken	0.066	0.018
Pork	0.067	0.026
Lamb	0.007	0.000
Eggs	0.029	0.013
Potatoes	0.120	0.029
Green vegetables	0.087	0.037
Fruits	0.053	0.037
Root vegetables	0.043	0.037
Tinned green vegetables	0.015	0.007
Tinned fruit	0.021	0.032
Tinned root vegetables	0.015	0.007

Considering food consumption, it is assumed that only a fraction, depending on the product (see next table), comes from the vicinity of the damaged plant.

SUB-CHAPTER 2.1 - TABLE 2

Contaminated fraction

Product	
Milk	100%
Vegetables (green and root vegetables and potatoes)	70%
Meat (beef, lamb, pork, chicken), eggs	50%
Other products : butter, cheese, meal, tinned milk, tinned vegetables	10%

SUB-CHAPTER 2.1 – TABLE 3

Time spent indoors / Shielding factors

	Adult	Infant (1 y)
Time spent indoors/day (h)	14	20
Shielding factor$_{rb}$	0.1	0.1

SUB-CHAPTER 2.1 – REFERENCES

External references are identified within this sub-chapter by the text [Ref-1], [Ref-2], etc at the appropriate point within the sub-chapter. These references are listed here under the heading of the section or sub-section in which they are quoted.

[Ref-1] European Utility Requirements for LWR nuclear power plants. Volume 2 - Generic nuclear island requirements. Revision C. EUR document. April 2001. (E)

1. HEAT SINK

[Ref-1] European Utility Requirements for LWR nuclear power plants. Volume 2 - Generic nuclear island requirements. Revision C. EUR document. April 2001. (E)

2. GRID CONNECTIONS

[Ref-1] European Utility Requirements for LWR nuclear power plants. Volume 2 - Generic nuclear island requirements. Revision C. EUR document. April 2001. (E)

3. DENSITY AND DISTRIBUTION OF LOCAL POPULATION

[Ref-1] Nuclear Electric. Safety Review Guidebook for Gas Cooled Reactors. Nuclear Electric Report TD/NS/REP/0243/B, Issue 1. September 1993. (E)

4. MAN-MADE EXTERNAL HAZARDS

4.1. ACCIDENTAL AIRCRAFT CRASH

[Ref-1] Civil Aviation Authority. Structure and operation of UK airspace. Environmental Information Sheet No.3. UK Civil Aviation Authority, Directorate of Airspace Policy. 2006. (E)

[Ref-2] Health and Safety Executive. The calculation of aircraft crash risk in the UK, prepared by AEA Technology plc for the HSE. Contract Research Report 150/1997. (E)

4.3. MALICIOUS ACTIVITY

[Ref-1] European Utility Requirements for LWR nuclear power plants. Volume 2 - Generic nuclear island requirements. Revision C. EUR document. April 2001. (E)

5. NATURAL EXTERNAL HAZARDS

5.2. EXTREME WEATHER CONDITIONS

[Ref-1] UK Met Office website - http://www.metoffice.gov.uk/

5.2.1. Strong winds

[Ref-1] UK Health and Safety Executive (HSE). Safety Assessment Principles for Nuclear Facilities. 2006 Edition Revision 1. January 2008. (E)

5.2.2. Tornadoes

[Ref-1] TORRO Organisation website - HTTP://WWW.TORRO.ORG.UK/TORRO/ (E)

5.3. BIOLOGICAL HAZARDS

5.3.2. Animal infestation

[Ref-1] European Utility Requirements for LWR nuclear power plants. Volume 2 - Generic nuclear island requirements. Revision C. EUR document. April 2001. (E)