

Chapelcross: Response to EU Stress Tests following the Events at Fukushima, Japan



Following the nuclear accident at Fukushima in Japan, the European Union agreed on assessments for all of its 143 nuclear power plants, based on a set of common criteria. These criteria have been developed by ENSREG (the European Nuclear Safety Regulators Group) and have become known as 'Stress Tests'.

In response to the Stress Tests, operators of UK nuclear power plants have reviewed the resilience of their plants to extreme situations, in particular the loss of safety functions however caused, including the loss of electrical power or loss of ultimate heat sink for heat removal from the reactor or spent fuel storage areas.

This report details the results of the Stress Tests for Chapelcross Site. It has been submitted to the Office for Nuclear Regulation (an agency of the Health and Safety Executive) who will review all UK submissions and prepare a summary national report. This will be reviewed by ENSREG who will report to the European Council in June 2012.

Issued by... 

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Executive Summary

This report is the response from Chapelcross Site to the ENSREG Stress Tests following the events at Fukushima, Japan in March 2011.

Chapelcross Site comprises of 4 Magnox, gas cooled, graphite moderated, natural and enriched uranium reactors which have been closed down and rendered passively safe since shutdown was completed in 2004. Defuelling operations, which commenced in 2008 and are currently approaching the halfway point, are due to complete in 2013.

The site ponds are not required for defuelling operations and are currently either being used to store Intermediate Level Waste (ILW) or are actively being drained for decommissioning activities to proceed. All known fuel has been removed previously.

The most recent seismic reviews of the site (undertaken for the 2009 Periodic Safety Review (PSR)) have confirmed that the reactors currently do not satisfy the 10^{-4} per annum design basis earthquake withstand. However the overall risk associated with this shortfall will be rendered negligible when the defuelling process is complete within the next two years.

Due to the location and topography of the site the threat from flooding either from the sea or from an extreme weather event is considered to be incredible.

On-site contingency exists to support the Chapelcross power requirement should national or local transmission services fail, however due to the passively safe nature of the reactors and ponds, the total loss of power would in the short term not present a threat to the site.

A series of workshops has been held to identify potential measures to enhance resilience in the event of external hazards or severe accidents, and those being considered for implementation are listed in Table 1. The site will also be supported by enhancements proposed for central emergency support.

1 General data about site/plant

1.1 Brief description of the site characteristics

- location (sea, river)¹
- number of units;
- license holder

Chapelcross is located in South West Scotland, United Kingdom approximately 5 km north of the Solway Firth.

The site contains four “Magnox” reactors, which have been permanently shut down since 2004 and are currently in the process of being defuelled. The site has two cooling ponds; one of which is drained for decommissioning and one storing ILW. The Chapelcross Processing Plant (CXPP) is no longer used for processing but does contain an inventory of ILW.



The general level of the Chapelcross site is approximately 74m above sea level.

Magnox Limited is the Site Licence holder for the Chapelcross nuclear licensed site.

1.2 Main characteristics of the unit

- reactor type;
- thermal power;
- date of first criticality;
- existing spent fuel storage (or shared storage).

Reactors

The site consists of 4 graphite moderated, gas cooled reactors utilising both natural and slightly enriched uranium fuel in magnesium alloy cans. In total the four reactors were capable of generating 1000MW (thermal) at power.

During operation, the core was cooled by forced circulation of carbon dioxide gas through the core and water fed boilers. The reactor core is contained within a mild steel pressure vessel within a concrete biological shield, connected by mild steel gas ducts to four heat exchangers (boilers) located externally at the four corners of the building. Reactivity was controlled by boron steel control rods; which on reactor trip fell by gravity into the core. During operation, post-trip cooling of the reactor cores was provided by forced circulation of the carbon dioxide coolant, with feed water supplied to the boilers.

Following reactor shutdown, and as decay heat in the fuel has reduced with time, the cooling provisions for the core have been progressively reduced and withdrawn. The Thermal Power of each reactor is approximately 10kW, which comprises residual decay heating originating from radioactive by-products of the fission process.

¹ Text and headings which are in a smaller font are relevant extracts from the ENSREG Stress Test documentation and not part of the Stress Test response.

The reactors have now been fully isolated from the boilers by closure of the isolating valves on the inlet and outlet ducts. Core cooling is now limited to natural heat loss through the reactor pressure vessel walls to the air in the reactor void (between the reactor vessel and the bioshield). Reactor void air is ambient air that is drawn in at lower level and exits via the reactor stacks by natural circulation only.

Peak fuel element temperatures in all reactors are in the range 25 °C to 35 °C. They vary by about 10°C between summer and winter in line with ambient weather conditions. Graphite temperatures are a few degrees below fuel temperatures.

The reactor pressure vessels are maintained at a pressure of 2 psig by application of dry air, regulated by pressure relief valves, to ensure that even during long term storage, in-reactor conditions do not lead to significant oxidation of the fuel cans or other reactor components. Normal moisture levels in the reactor vessels are in the range 50-100vpm, compared to an Operating Rule limit of 4500 vpm.

Dry air is supplied by two dry air plants, both of which can be configured to support all 4 reactors.

Reactor Details

Reactor	First Criticality	Shutdown
1	9 th Nov. 1958	31 st Aug 2001
2	30 th May 1959	17 th Feb.2004
3	31 st Aug. 1959	17 th May 2003
4	22 nd Dec. 1959	14 th Feb.2003

Ponds

The Chapelcross cooling ponds consists of 2 large concrete tanks providing storage at depths of approximately 6m. One of the ponds is now drained as part of a decommissioning programme while the second is functioning as an ILW storage facility with an inventory comprising of cobalt cartridges, zeolite resins, miscellaneous activated components (MAC) and sludge.

The defuelling process (started 18th August 2008) does not require the use of the cooling ponds for cooling or shielding. Fuel removed from the core is transferred directly to M2 flasks for road shipment to Sellafield.

The Chapelcross effluent pipeline is used to transfer water waste from the detention tanks in the ponds building to the Solway Firth (approximately 6km) after regulatory requirements have been satisfied.

Chapelcross Processing Plant

All process operations within the CXPP have now ceased and the facility is being used as a temporary store for solid ILW.

B141

B141 is essentially a storage building which was upgraded to provide enhanced weather protection by construction of a steel clad overbuilding. The building currently stores a range of ILW.

1.3 Systems for providing or supporting main safety functions

In this chapter, all relevant systems should be identified and described, whether they are classified and accordingly qualified as safety systems, or designed for normal operation and classified to non-nuclear safety category. The systems description should include also fixed hook-up points for transportable external power or water supply systems that are planned to be used as last resort during emergencies.

1.3.1 Reactivity control

Systems that are planned to ensure sub-criticality of the reactor core in all shutdown conditions, and sub-criticality of spent fuel in all potential storage conditions. Report should give a thorough understanding of available means to ensure that there is adequate amount of boron or other respective neutron absorber in the coolant in all circumstances, also including the situations after a severe damage of the reactor or the spent fuel.

The reactors are permanently shutdown, with large excess reactivity margins (>2 Niles) against all credible reactor fault conditions. This is achieved by:

- Permanent insertion of all control rods located in evenly distributed interstitial channels in each reactor.
- Permanent deployment of all boron ball shutdown devices (BBS), located in evenly distributed interstitial channels in each reactor
- Providing administrative controls on the removal of control rods, and the selection of channels from which fuel may be removed.
- Maintaining core temperature below 100°C.

(The Magnox core has a large positive moderator temperature coefficient of reactivity of the order of +10mN/°C. Thus, now that the core is well below the historical operating temperatures of 160-390°C there is a significant beneficial effect on maintaining the reactor shut down margin.)

1.3.2 Heat transfer from reactor to the ultimate heat sink

- 1.3.2.1 All existing heat transfer means / chains from the reactor to the primary heat sink (e.g., sea water) and to the secondary heat sinks (e.g., atmosphere or district heating system) in different reactor shutdown conditions: hot shutdown, cooling from hot to cold shutdown, cold shutdown with closed primary circuit, and cold shutdown with open primary circuit.

The reactors are now shutdown, passively cooled and the cores are at ambient temperature.

Core cooling is now limited to natural heat loss through the reactor pressure vessel walls to the air in the reactor void (between the reactor vessel and the bioshield). Reactor void air is ambient air that is drawn in at lower level and exits via the reactor stacks. Although not claimed as a safety measure, it would

still be possible to increase the cooling effect in the void by running the existing void fans.

Tests on site have demonstrated that the core temperature cannot exceed 100°C.

- 1.3.2.2 Lay out information on the heat transfer chains: routing of redundant and diverse heat transfer piping and location of the main equipment. Physical protection of equipment from the internal and external threats.

Each reactor was originally connected to 4 heat exchangers by inlet and outlet ductwork. The heat exchangers are no longer functional, having been drained and isolated from the cooling water supply. The 54" valves on each outlet and inlet line, which isolate the reactors from the heat exchangers, have now also been closed. Each reactor is currently served by a single void fan (415V, AC supply) located above the pile cap. The main duty of the fan is to provide local extraction ventilation during the defuelling process.

- 1.3.2.3 Possible time constraints for availability of different heat transfer chains, and possibilities to extend the respective times by external measures (e.g., running out of a water storage and possibilities to refill this storage).

The option exists to use the void vent fan system to actively circulate air in the void to assist cooling process. There are no time constraints to implement this option.

- 1.3.2.4 AC power sources and batteries that could provide the necessary power to each chain (e.g., for driving of pumps and valves, for controlling the systems operation).

Under normal operation no AC power source is required as the system is passive. The void fan system, if deployed, would run on 415V supply from the reactor building switchboards but has no back up battery

- 1.3.2.5 Need and method of cooling equipment that belong to a certain heat transfer chain; special emphasis should be given to verifying true diversity of alternative heat transfer chains (e.g., air cooling, cooling with water from separate sources, potential constraints for providing respective coolant).

No cooling equipment required for current plant arrangements, however forced air cooling fans provide a back up if required.

1.3.3 Heat transfer from spent fuel pools to the ultimate heat sink

- 1.3.3.1 All existing heat transfer means / chains from the spent fuel pools to the primary heat sink (e.g., sea water) and to the secondary heat sinks (e.g., atmosphere or district heating system).

Not Applicable.

The Chapelcross defuelling process has been configured to function independently of the cooling ponds and hence the cooling ponds have not been used to cool or store spent fuel since 2006.

- 1.3.3.2 Respective information on lay out, physical protection, time constraints of use, power sources, and cooling of equipment as explained under 1.3.2.

Not relevant to the Chapelcross site as ponds no longer have a fuel cooling function.

1.3.4 Heat transfer from the reactor containment to the ultimate heat sink

In the Magnox design the reactor vessel provides the reactor containment (the covering building providing protection of plant from the environment). Cooling of the reactor internals and the pressure vessel is covered in section 1.3.2.

- 1.3.4.1 All existing heat transfer means / chains from the containment to the primary heat sink (e.g., sea water) and to the secondary heat sinks (e.g., atmosphere or district heating system).

The reactor vessel, which provides the reactor containment, is cooled by the reactor cooling systems described in section 1.3.2.1. The vessel support structures are then adequately cooled by passive heat transfer to the environment.

- 1.3.4.2 Respective information on lay out, physical protection, time constraints of use, power sources, and cooling of equipment as explained under 1.3.2.

The reactor vessel, which provides the reactor containment, is cooled by the reactor cooling systems described in Section 1.3.2.1. The layout, protection, time constraints, power sources and cooling of these systems is described in sections 1.3.2.2-5. No further systems are necessary for the vessel support structures. .

1.3.5 AC power supply

1.3.5.1 Off-site power supply

- 1.3.5.1.1 Information on reliability of off-site power supply: historical data at least from power cuts and their durations during the plant lifetime.

There have been no off-site power cuts affecting the main Scottish Power (SP) substation since shutdown in 2004. A number of power cuts have been reported all affecting the separate 11kV supply to facilities on the north side of the site.

- 1.3.5.1.2 Connections of the plant with external power grids: transmission line and potential earth cable routings with their connection points, physical protection, and design against internal and external hazards.

The site is supplied by five 132kV grid lines from three different substations all feeding into the on-site (SP) substation.

A separate power supply taken directly from the local area distribution system (11kV) is transformed to 415V and used to supply the Flask Handling Building, B141 (ILW waste) and contractor compound.

1.3.5.2 Power distribution inside the plant

1.3.5.2.1 Main cable routings and power distribution switchboards.

The 132kV supply is fed from the SP substation to the turbine hall where the supply is transformed to 11kV (currently using two transformers) which in turn is then connected to the turbine hall 11kV switchboard. The turbine hall switchboard is connected via underground cable routes to each of the four 11kV Reactor switchboards which in turn are used to support a number of site services through the following distribution network:

- Two 11kV feed lines to CXPP.
- 11kV to 415V transformers within the reactor buildings which support reactor building services and instrumentation via the reactor 415V switchboards.
- 11kV line back to the turbine hall which is transformed down to 3.3kV and connected to the 3.3kV switchboard. The turbine hall 415V requirements are provided by transforming the 3.3kV supply to 415V.
- The ponds building is supplied from reactor 3 and reactor 4 switchboards (415V).
- All four reactors buildings are also interconnected via 11kV underground cabling.

1.3.5.2.2 Lay-out, location, and physical protection against internal and external hazards.

The layout and locations are indicated in the section above. Transformers (11kV) in the turbine hall are protected by fire detection and suppression systems which are supported by battery back up. 11kV Transformers in the reactor buildings have no detection or suppression systems. The 11kV switchrooms in the turbine hall and reactors have automatic detection and carbon dioxide suppression systems. The 415V and 3.3kV transformers in both reactor buildings and turbine hall have fire detection but no suppression systems.

Cable basements in the reactor buildings have automatic detection and suppression fire systems.

Although the cabling provides resistance to water submersion it is recognised that the age of the system could pose problems in future. This will be remedied through completion of the Electrical Overlay project.

1.3.5.3 Main ordinary on-site source for back-up power supply

1.3.5.3.1 On-site sources that serve as first back-up if offsite power is lost.

In the first instance the battery systems (as described in section 1.3.6) will provide supplies while the main AC back up mobile diesel alternators are brought into service.

The Chapelcross site is provided with two mobile 500kVA diesel alternators which can be connected to each of the Reactor electrical distribution systems or to the turbine hall 415V supplies. The units provide a 415V supply to support site communications, site fire alarm panel UPS, main and alternative Emergency Control Centre UPSs, and Emergency Access Control Points.

No claim is made regarding reactor safety systems or shutdown systems.

CXPP has two stand-by diesel alternators and an underground diesel supply capable of maintaining CXPP ventilation system should offsite power be lost.

The mobile alternators can also supply the Ponds building by connection via reactor 3 or 4, 415V switchboards.

1.3.5.3.2 Redundancy, separation of redundant sources by structures or distance, and their physical protection against internal and external hazards.

Two mobile alternators are held on site, mounted on trailers and enclosed in a weather proof container. The units are parked close to the roadway and away from any major structure likely to be compromised by a seismic event. The batteries serving the starter motor are permanently on charge.

Redundancy of supply is also supported by the fact that there are alternator connection points in different locations.

In an emergency the connection point selected for the mobile alternators would be at the discretion of the emergency controller and the supporting team. As the reactors are now considered to be passively safe any emergency situation would most likely result in the mobile alternator being connected to supply the Emergency Control Centre (ECC) and the Access Control Point (ACP). It should be noted however that this connection will also supply the Alternative ECC (AECC) located in the training centre and the Alternative ACP (AACP), should the ECC or ACP become untenable.

It is also possible to supply power to the AACP from one of the other connection points. With some minor switching it is also possible to supply the AECC from that connection.

Each alternator connection point is protected with a Castell key system which ensures existing AC 415V supplies are isolated before the mobile unit can be brought on line and hence prevents the alternators being paralleled with the grid supplies.

To ensure the units are permanently available a number of checks, sanctioned by Plant Maintenance Schedule part 2, are in place:

- Units have a monthly routine test and light run (includes check on that the fuel level is above a specified minimum and is verified by visual or dip check)
- Monthly battery check
- Annual Load test and annual Inspection and maintenance.

- 4 yearly checks/maintenance are carried on switchboard circuit breakers and busbars.

1.3.5.3.3 Time constraints for availability of these sources and external measures to extend the time of use (e.g., fuel tank capacity).

Although there are no reactor safety time constraints the mobile alternators are held in readiness to be brought into service within an hour.

The main time constraints are associated with the on site transport of the unit (which requires a tractor to mobilise) and the time required to connect the supply. Each shift however has a complement of trained personnel to make the connections.

Each diesel unit is provided with sufficient diesel fuel for a minimum of 24h operation at full load (ie total time for two units = 48hours). In the event that off site diesel supplies are disrupted, further on-site sources of fuel could be brought on line: CXPP emergency generator tanks, site locomotive tank and garage reserve fuel stock.

1.3.5.4 Diverse permanently installed on-site sources for back-up power supply

1.3.5.4.1 All diverse sources that can be used for the same tasks as the main back-up sources, or for more limited dedicated purposes (e.g., for decay heat removal from reactor when the primary system is intact, for operation of systems that protect containment integrity after core meltdown).

There are no diverse permanently installed on-site sources at the Chapelcross site.

1.3.5.4.2 Respective information on location, physical protection and time constraints as explained under 1.3.5.3.

There are no diverse permanently installed on-site sources at the Chapelcross site.

1.3.5.5 Other power sources that are planned and kept in preparedness for use as last resort means to prevent a serious accident damaging reactor or spent fuel

1.3.5.5.1 Potential dedicated connections to neighbouring units or to nearby other power plants.

There are no neighbouring sites to Chapelcross, therefore this question is not relevant.

1.3.5.5.2 Possibilities to hook-up transportable power sources to supply certain safety systems.

The site has in the past hired diesel alternators from local contractors during periods of maintenance of the existing units. It is anticipated that any system brought on site would be compatible with current arrangements for the mobile alternators.

- 1.3.5.5.3 Information on each power source: power capacity, voltage level and other relevant constraints.

Any mobile alternator system would be a direct replacement for the 415V mobile alternators currently on site.

- 1.3.5.5.4 Preparedness to take the source in use: need for special personnel, procedures and training, connection time, contract arrangements if not in ownership of the Licensee, vulnerability of source and its connection to external hazards and weather conditions.

It is anticipated that any system brought on site would be compatible with current arrangements for the mobile alternators.

1.3.6 Batteries for DC power supply

- 1.3.6.1 Description of separate battery banks that could be used to supply safety relevant consumers: capacity and time to exhaust batteries in different operational situations.

There are a number of different battery systems on the Chapelcross site. Details below (1.3.6.2).

- 1.3.6.2 Consumers served by each battery bank: driving of valve motors, control systems, measuring devices, etc.

1. 240V and 50V batteries located at ground floor level are required to support 11kV switching equipment (and associated trip systems). These batteries also support the grid transformer fire fighting system and some of the reactor lighting requirements.
2. 50V batteries in the reactor building supply essential services of 11kV and 415V switch gear and fire alarm systems.
3. A 330V battery supports the Uninterrupted Power Supply (UPS) System for the Emergency Control Centre (ECC), role call, site siren and Fire Thorn Graph.
4. Two 330V batteries support the UPS for Alternative Emergency Control Centre (AECC).
5. A 240V battery supports UPS for Data logging equipment (note: reactor data logging can be carried out manually if required).
6. A 440V battery supports UPS for IT servers and equipment.
7. A 240V battery supports security.
8. A 120V battery supports security.
9. The reactor emergency lights are fitted with individual back-up batteries.
10. CXPP has a number of batteries as follows:
 - a. 110V for electrical switching equipment
 - b. 2x24V batteries to start back up emergency diesel alternators.
 - c. 110V battery for cave lighting.

- d. 24V battery for building evacuation siren.
- e. 240V to support building inverter for instrumentation.

11. Each Emergency Plume Gamma Monitoring System (EPGMS) station is fitted with two 12V VRLA batteries with in built recharge facilities provided by solar and wind generated systems attached individually to each unit.

- 1.3.6.3 Physical location and separation of battery banks and their protection from internal and external hazards.

The locations of the battery systems is indicated above (1.3.6.2).

- 1.3.6.4 Alternative possibilities for recharging each battery bank

Batteries would be recharged by use of the mobile diesel alternators when connected to the reactor or turbine hall connection points.

1.4 Significant differences between units

This chapter is relevant only for sites with multiple NPP units of similar type. In case some site has units of completely different design (e.g., PWR's and BWR's or plants of different generation), design information of each unit is presented separately.

Chapelcross has 4 Magnox reactors of a similar design. The only significant design difference between reactors is that reactors 2, 3 and 4 fuel channels are fitted with graphite sleeves while reactor 1 remained unsleeved

1.5 Scope and main results of Probabilistic Safety Assessments

Scope of the PSA is explained both for level 1 addressing core meltdown frequency and for level 2 addressing frequency of large radioactive release as consequence of containment failure. At each level, and depending on the scope of the existing PSA, the results and respective risk contributions are presented for different initiating events such as random internal equipment failures, fires, internal and external floods, extreme weather conditions, seismic hazards. Information is presented also on PSA's conducted for different initiating conditions: full power, small power, or shutdown.

The most recent Probabilistic Safety Assessment carried out for Chapelcross assessed the frequency of failing to trip, shutdown or post trip cool the reactors whilst they were at power. Now that the reactors are shutdown, de-pressurised and cooled passively by natural circulation of air, the radiological consequences of fault sequences are much reduced compared to those that existed when the reactors were at power. The radiological hazard at the site continues to decrease as defuelling progresses.

2 Earthquakes

2.1 Design basis

2.1.1 Earthquake against which the plant is designed

2.1.1.1 Characteristics of the design basis earthquake (DBE)

Level of DBE expressed in terms of maximum horizontal peak ground acceleration (PGA). If no DBE was specified in the original design due to the very low seismicity of the site, PGA that was used to demonstrate the robustness of the as built design.

Seismic hazards were not included within the original design basis for the Chapelcross Power Station. Subsequent assessments have assigned a design basis earthquake for the Chapelcross site as 0.25g (Peak Free-Field Horizontal Acceleration; PFFHA) for a $10^{-4}y^{-1}$ event.

2.1.1.2 Methodology used to evaluate the design basis earthquake

Expected frequency of DBE, statistical analysis of historical data, geological information on site, safety margin.

A seismic hazard assessment for the Chapelcross site was performed in the early 1980s by Principia Mechanical Limited (PML) and made use of the available reliable information concerning the history of earthquakes in the UK to provide a probabilistic estimate of seismic hazard at the site. The analysis showed that at the Chapelcross site the risk was greater than the average for the UK; for a 10^{-4} per annum event the PFFHA is close to 0.25g compared to the UK average of 0.19g. In defining the input time histories to seismic analysis and assessment, the nature of the site needed to be classified based on the ground conditions and the soil type. The different sites are classified based on frequency of response of the free-field soil column. Frequencies of less than 3Hz are classified as soft sites, between 3 and 10Hz as intermediate or medium sites and greater than 10Hz as hard sites. Therefore, as the foundation for the Chapelcross Reactors 1 and 2 is rock, the site was classified as hard.

Below Reactors 3 and 4 the ground was found to have a natural frequency of about 9Hz, implying an intermediate site. However, since the reactors were founded on rock a hard site input was applied at the rock foundation interface in the initial PML work. This assumption was later found to be conservative and was then modified with subsequent analyses using the intermediate site classification.

The initial PML analyses used time histories taken from a suite of nine generated to match the UK design spectra for the three site classifications. The vertical time histories were scaled to 2/3 of the horizontal input. A revised analysis incorporated more detailed modelling of the soil profiles for the Chapelcross Reactors 3 and 4 sites. This work used one real time history, Forgania, plus two artificial time histories.

2.1.1.3 Conclusion on the adequacy of the design basis for the earthquake

Reassessment of the validity of earlier information taking into account the current state-of-the-art knowledge.

The UK as a whole is a region of relatively low-level and diffuse seismic activity. No specific geological or tectonic features have been identified that would suggest that earthquakes larger than those considered in the studies underpinning the Chapelcross design basis event are credible. Examination of the pattern of historical UK seismicity indicates that Chapelcross is situated in a region of relatively high earthquake activity by UK standards and this is reflected in the higher than the UK average predicted 10^{-4} per annum exceedance frequency peak ground acceleration.

Knowledge of UK seismicity has increased somewhat since the Chapelcross design basis was established and methods for seismic hazard analysis continue to advance. Nevertheless, a recent review for the PSR considered that the design basis earthquake is an adequately bounding representation of the prevailing seismic hazard for Chapelcross at a 10^{-4} per annum exceedance frequency.

2.1.2 Provisions to protect the plant against the design basis earthquake

2.1.2.1 Systems Structures and Components (SSCs)

Identification of systems, structures and components (SSC) that are required for achieving safe shutdown state and are most endangered during an earthquake. Evaluation of their robustness in connection with DBE and assessment of potential safety margin.

The reactors have been shutdown since 2004 and therefore the main identifiable risks are associated with re-criticality and loss of containment in event of an earthquake.

Key Structures	Seismic withstand
Bioshield	>0.2g
Pressure circuit	0.21g
Pressure vessel	0.24g
Core (lateral restraint)	0.24g
Reactor building roof	0.68g
Heat exchangers	0.29g
Reactor stacks	0.54g
Ponds structure	0.21g
CXPP cave (concrete structure)	>0.25g

Key Systems

- Control rods and BBSD system (seismically qualified to >0.25g)

From the seismic information tabulated above the assessment of 0.2g is based on the bioshield and pressure circuit values. The pressure vessels and core constraints are marginally outside the design basis while much of the rest of the building structure (which could threaten containment) such as the roof and stacks have sufficient withstand.

For the CXPP, the cave concrete structure is seismically qualified but the zinc bromide windows are not. Failure of the window could result in a dose of <250mSv to an operator, negligible dose to the public.

On the basis of existing information it is not possible to provide a rigorous quantified judgement of the available safety margin. It is noted however, that some structures and components have been assessed to be highly utilised under the design seismic demand, albeit using a pessimistic approach. As a consequence, a large margin beyond the design basis would not be anticipated.

2.1.2.2 Main operating contingencies in case of damage that could be caused by an earthquake and could threaten achieving safe shutdown state.

Operations to be carried out following an earthquake consistent with the design basis event would be determined by the shift manager/emergency operations controller in accordance with station operating procedures. Actions taken will depend upon impact of the event on plant and systems availability and could, if judged appropriate, result in declaration of a Site Incident or an Off Site Nuclear Emergency.

The duty emergency controller and emergency response team will then be called to the site and they will assume control of operations from the Emergency Control Centre (ECC).

Reactors

No specific actions required at the Chapelcross site as the reactors are already shutdown and sufficient passive measures are in place to protect against re-criticality.

Reactor parameters such as core temperatures can be monitored from the ECC. However existing site procedures (ODPI P1: Actions to be Taken in Event of an Earth Tremor) directs specified walkdowns and inspections for a tremor of 0.035g or greater.

Ponds

Site procedure “Pond Emergency Guidelines” provides information and options available to the emergency response team. Pond damage as a result of an earthquake could result in loss of pond water leading to an off site contamination and loss of shielding within the pond itself, giving rise to dose rates of the order of 100-200mSv/h at the edge of the pond. Operationally two options exist :

1. Allow the pond to drain and withdraw personnel.
2. Top up the pond using water from nearby hydrants. Hoses for this purpose are held on the Emergency Response Vehicles.

The long term strategy for pond ILW will consist of retrieval and packaging in Ductile Cast Iron Containers (DCICs) for storage.

CXPP

In event of a seismic event the building would be evacuated. Procedure PI 1.5 (“Action to be taken in the Event of an Earth Tremor”) identifies actions required to make the plant safe, evacuation and what initial inspections to carry out.

Failure of the zinc bromide window would be detected by window level alarm, gamma monitors and visually by the operator. The PSR considered the provisions for the cave windows to be ALARP.

As for the pond building, the company strategy is that ILW from this facility will be transferred to DCICs for long term storage.

2.1.2.3 Protection against indirect effects of the earthquake

- 2.1.2.3.1 Assessment of potential failures of heavy structures, pressure retaining devices, rotating equipment, or systems containing large amount of liquid that are not designed to withstand DBE and that might threaten heat transfer to ultimate heat sink by mechanical interaction or through internal flood.

The failure of structures, causing an indirect risk, are included in seismic assessment. (section 2.1.2.1 above)

- 2.1.2.3.2 Loss of external power supply that could impair the impact of seismically induced internal damage at the plant

Not applicable to the Chapelcross site as the reactors are shutdown and there are no identified requirements for external power.

- 2.1.2.3.3 Situation outside the plant, including preventing or delaying access of personnel and equipment to the site.

In the event of a significant seismic event, disruption to local communication routes can be assumed, resulting in restricted access for emergency response personnel, relief staff and the local fire service. However the site has 4 access gateways which utilise 2 different local roadways offering some options if individual access roads are affected.

One further gate allows access to the helicopter landing site.

In terms of access to national routes providing support to the site in an emergency, it should be noted that the site is located approximately 3 miles from the main north-south motorway (M74) and approximately 2 miles from the main east-west artery (A75).

- 2.1.2.3.4 Other indirect effects (e.g. fire or explosion)..

The only relevant indirect effect of a seismic event at Chapelcross is a potential for fire from ruptured fuel (diesel) tanks or lines.

In conjunction with this there could be damage to the water mains which would restrict fire fighting capabilities. To some extent mitigation does exist in that a limited quantity of water is normally carried by the fire tenders (x2),

which could additionally leave site to restock if possible. The site is otherwise reliant on the local fire service for support.

2.1.3 Compliance of the plant with its current licensing basis

2.1.3.1 Processes to ensure SSCs remain in faultless condition

Licensee's processes to ensure that plant systems, structures, and components that are needed for achieving safe shutdown after earthquake, or that might cause indirect effects discussed under 2.1.2.3 remain in faultless condition.

The plant is subject to routine maintenance, inspection and testing as required by the Plant Maintenance Schedule (PMS) which lists those activities that are necessary to support the site safety case. (SLC 28)

A schedule of Civil Structural Inspections has been introduced to the Chapelcross site to ensure that all nuclear significant structures are inspected on a routine basis by suitably qualified personnel and that all faults and shortcomings identified are addressed by the site. The inspections are prompted by part 2 of the PMS with the calendar of inspections listed in EP45. (SLC 28)

All modifications to the plant structure, equipment, procedures or safety cases must be justified by a Plant Modification Proposal (PMP) or a Plant Safety Paper (PSP) and must be categorised according to the dose consequence attributed to the worst credible fault. The level of approval required (ie from a site level (Plant Safety Panel) to a corporate level (Nuclear Safety Committee)) is determined by the category of the proposed change. (SLC 19, 29, 21, 22, 35)

At 10 yearly intervals, and in response to significant operating events, the safety of the plant is reviewed in a periodic safety review. This reviews the plant against modern standards, operating experience and the effects of ageing. Enhancements identified in the periodic safety reviews carried out to date have been implemented.

2.1.3.2 Processes for mobile equipment and supplies

Licensee's processes to ensure that mobile equipment and supplies that are planned to be available after an earthquake are in continuous preparedness to be used.

Mobile Diesel Alternators

The two mobile diesel alternators are entered on the PMS part 2: Plant Section 5: Essential Electrical Systems, item number 5.19 which mandates 10 routine maintenance activities necessary to ensure continuous preparedness. The tests include monthly "Routine test and light run" and monthly "Battery Check" in addition to annual "Load Test" and "Inspection and Maintenance".

Emergency Handbook Section 16 provides a detailed list of equipment to be held in readiness for an emergency. This document identifies the equipment, number required, location of storage, department responsible, inspection frequency (monthly or weekly) and maintenance schedule.

The Company shares a Beyond Design Basis Accident Container set in a central location in the UK that can be transported to any affected site. These containers are equipped with Command and Control, fire fighting, reactor cooling and contamination control materials.

2.1.3.3 Potential deviations from licensing basis

Potential deviations from licensing basis and actions to address those deviations.

As part of the actions arising from the 2009 PSR a review of the Chapelcross seismic withstand against modern standards was undertaken. This concluded that a 0.2g seismic withstand for the reactor facilities was valid subject to ongoing inspection and maintenance activities.

The seismic withstand of core structures and adjacent civil structures (0.2g) falls short of the identified standard capability (0.25g) as the postulated 0.2g event occurs more frequently in this area than 10^{-4} per annum design basis.

This shortfall however needs to be considered against a number of factors:

- The initial assessment was a very conservative case based on a station at full power.
- The defuelling process represents a significant reduction in the overall hazard. Defuelling is currently scheduled to complete in April 2013.
- The hazard will continue to reduce incrementally in line with the reactor fuel inventory, until effectively becoming negligible when all the fuel is removed.
- The scope of any remedial work necessary to bring the reactor up to the full 0.25g qualification has not been assessed, but will certainly entail commitment of additional finance and resource, will present its own set of risks, will potentially complicate and possibly delay defuelling, and may not be complete before the defuelling process has removed the hazard completely.

The ponds again fall short of the design basis withstand but are currently undergoing work to decommission and remove the present ILW inventory which is viewed as the optimum solution. Decommissioning is expected to be complete by mid 2015.

In conclusion therefore is considered that the best option to address the shortfall in seismic withstand for the Chapelcross site is to remove the hazard by completing the defuelling process.

2.2 Evaluation of safety margins

2.2.1 Range of earthquake leading to severe fuel damage

Weak points and cliff edge effects: estimation of PGA that would result in damage to the weakest part of heat transfer chain, and consequently cause a situation where the reactor integrity or spent fuel integrity would be seriously challenged.

No estimate of the Peak Ground Acceleration (PGA) which would threaten the reactor integrity or fuel integrity has been assessed for the Chapelcross site.

However from consideration of the table in section 2.1.2.1 the following scenarios may be postulated:

- For seismic events in excess of 0.21g structural failure of the bioshield and primary circuit could arise, resulting in a partial loss of shielding of the reactor and the possibility of a release of contaminated reactor air.
- For seismic events corresponding to the Design Basis (0.25g) failure of the pressure vessel and core restraints could occur leading to a restriction to the cooling air flow around the pressure vessel and possible mechanical damage to the fuel.
- Collapse of the core through failure of the supporting diagrid would also potentially result in fuel damage.
- In terms of re-criticality damage to, or collapse of, the pressure vessel would not be considered to pose a risk as the control rods and boron ball shutdown systems would still be fully deployed within the core.
- In the case of core collapse it is noted that the control rods, which are anchored from the charge pans, would be partially withdrawn from the core. However, the maximum relative movement between fuel rods and the fuelled core would not erode the shutdown margin to the point where criticality could occur.

2.2.2 Range of earthquake leading to loss of containment integrity

Estimation of PGA that would result in loss of integrity of the reactor containment.

Based on available data (see section 2.1.2.1), it is assumed that an earthquake giving rise to a peak ground acceleration in excess of 0.2g could result in failure of the integrity of the reactor primary circuit. It should be noted that whilst loss of containment of the primary circuit could result in a minor release of radioactivity to the environment, the reactors are depressurised and cool and the consequences of failure are orders of magnitude lower than for an operating reactor.

2.2.3 Earthquake exceeding the design basis earthquake for the plant and consequent flooding exceeding design basis flood

Possibility of external floods caused by an earthquake and potential impacts on the safety of the plant. Evaluation of the geographical factors and the physical possibility of an earthquake to cause an external flood on site, e.g. a dam failure upstream of the river that flows past the site.

External flooding has been considered to be incredible due to the geographical location of the site and the absence of any significant water source. (see section 3.1.1.1 below)

2.2.4 Potential need to increase robustness of the plant against earthquakes

Consideration of measures, which could be envisaged to increase plant robustness against seismic phenomena and would enhance plant safety.

The most significant measure to enhance safety in a seismic event, would be to continue the defuelling process and hence remove the hazard completely. Defuelling is now approaching the halfway point and is expected to complete in April 2013.

3 Flooding

3.1 Design basis

3.1.1 Flooding against which the plant is designed

3.1.1.1 Characteristics of the design basis flood (DBF)

Maximum height of flood postulated in design of the plant and maximum postulated rate of water level rising. If no DBF was postulated, evaluation of flood height that would seriously challenge the function of electrical power systems or the heat transfer to the ultimate heat sink.

- Tsunami: The site is approximately 5km from the coast and the Reactors and Cooling Ponds are located approximately 74m above sea level therefore risk from a Tsunami is not considered significant.
- River Flooding: The closest river to the site (River Annan) is approximately 2km from the site and approximately 40m below the site. No other major water source exists in the neighbourhood of the station.
- Precipitation: Extreme rainfall could result in 215mm of rain falling in a 24h period. This would cause localised flooding in some areas of the site but due to the general topography of the site and the passive nature of the reactor cooling, the water would not threaten safety significant plant.
- The demolition of the cooling towers and isolation of the main cooling water import line from the River Annan have also reduced the risk of flooding.

3.1.1.2 Methodology used to evaluate the design basis flood.

Reassessment of the maximum height of flood considered possible on site, in view of the historical data and the best available knowledge on the physical phenomena that have a potential to increase the height of flood. Expected frequency of the DBF and the information used as basis for reassessment..

Due to the location and elevation of the site the only potential source of water ingress to the site remains that of extreme precipitation. The 2009 PSR for the site identified the design basis rainfall for a 10^{-4} per annum event as 215mm in a 24h period (using statistical analysis of Meteorological Office rainfall records) and included a +5% factor for climate change.

3.1.1.3 Conclusion on the adequacy of protection against external flooding

This section addresses the adequacy of the design basis for flooding. The evaluation of safety margins against flooding is addressed in Section 3.2.

The location and topography of the site are considered to offer sufficient safeguard against flooding from the sea, including tsunami, and off-site water sources. Localised flooding at various areas around the site could arise from extreme rainfall but would not threaten the reactors or the ponds.

3.1.2 Provisions to protect the plant against the design basis flood

3.1.2.1 Systems Structures and Components (SSCs)

Identification of systems, structures and components (SSCs) that are required for achieving and maintaining safe shut down state and are most endangered when flood is increasing.

At Chapelcross the reactors are in a safe passive shutdown state and due to the topography and geographical location of the site the threat of a site flood is not considered credible.

Key Structures

- Reactor building
- Primary pressure circuit

Key systems

- Storm drain system prevents accumulation of rainwater.
- Cable basement and blower pit pumping arrangements

3.1.2.2 Main design and construction provisions

Main design and construction provisions to prevent flood impact to the plant.

Ponds

The ponds were built above ground with a 3.4m clearance between the ground surface and the pond lip and hence no impact from flooding is credible.

CXPP

The CXPP was constructed on elevated ground. From walk downs of the site it is apparent that flooding arising from heavy rainfall would follow the roadway away from the CXPP building and towards Gullielands burn at the lowest part of the site.

3.1.2.3 Main operating provisions

Main operating provisions to prevent flood impact to the plant.

Severe precipitation could affect the Chapelcross site and there are no specific site instructions relating to this type of occurrence. However, such an event would be indicated by forecasts and would therefore allow precautionary actions to be taken such as closing external doors and windows, checking and clearing drains, deploying sandbag protection if necessary and arranging an appropriate level of surveillance during and after the event.

3.1.2.4 Situation outside the plant, including preventing or delaying access of personnel and equipment to the site.

Situation outside the plant, including preventing or delaying access of personnel and equipment to the site.

In event of a flood or Tsunami in the local coastal area, disruption of the local infrastructure could be envisaged and hence access for personnel or equipment could be restricted. However this is unlikely to have a major impact as the site is situated on an inland location, on relatively high ground, with a number of gated access points allowing some diversity in terms of alternative approach routes. (see section 2.1.2.3.3)

3.1.3 Plant compliance with its current licensing basis

3.1.3.1 Processes to ensure SSCs remain in faultless condition

Licensee's processes to ensure that plant systems, structures, and components that are needed for achieving and maintaining the safe shut down state, as well as systems and structures designed for flood protection remain in faultless condition.

The plant is subject to routine maintenance, inspection and testing as required by the Plant Maintenance Schedule (PMS) which lists those activities that are necessary to support the site safety case. (SLC 28)

A schedule of Civil Structural Inspections has been introduced to the Chapelcross site to ensure that all nuclear significant structures are inspected on a frequent basis by suitably qualified personnel and that all faults and shortcomings identified are addressed by the site. The inspections are prompted by part 2 of the PMS with the calendar of inspections listed in EP45 (SLC 28).

All modifications to the plant structure, equipment, procedures or safety cases must be justified by a Plant Modification Proposal (PMP) or a Plant Safety Paper (PSP) and must be categorised according to the dose resulting from the worst credible fault. The level of approval required (ie from a site level to a corporate level) is determined by the category of the proposed change. (SLC 19, 20, 21, 22, 35)

A Periodic Safety Review (PSR) is undertaken on a minimum of a 10 yearly basis to confirm that the plant and claimed safety measures conform to modern standards, operating experience and allow for the effects of ageing. (SLC 15)

3.1.3.2 Processes for mobile equipment and supplies

Licensee's processes to ensure that mobile equipment and supplies that are planned for use in connection with flooding are in continuous preparedness to be used.

None identified.(see 2.1.3.2 above)

3.1.3.3 Potential deviations from licensing basis

Potential deviations from licensing basis and actions to address those deviations.

None identified.

3.2 Evaluation of safety margins

3.2.1 Estimation of safety margin against flooding

Estimation of difference between maximum height of flood considered possible on site and the height of flood that would seriously challenge the safety systems, which are essential for heat transfer from the reactor and the spent fuel to ultimate heat sink.

The location and topography of the Chapelcross site determine that the threat of flooding is extremely low. In addition the reactors are in a passively cooled state and are contained within a sealed system and hence even if flooding of the site were possible it would not effect the fuel. The ponds are no longer used to treat spent fuel and due to height of the pond surface above the local ground level, flooding is not credible.

3.2.2 Potential need to increase robustness of the plant against flooding

Consideration of measures, which could be envisaged to increase plant robustness against flooding and would enhance plant safety.

None identified for the Chapelcross site.

4 Extreme weather conditions

4.1 Design basis

4.1.1 Reassessment of weather conditions used as design basis

4.1.1.1 Characteristics of design basis extreme weather conditions

Verification of weather conditions that were used as design basis for various plant systems, structures and components: maximum temperature, minimum temperature, various type of storms, heavy rainfall, high winds, etc.

No design basis assessments informing the original design of the plant in the 1950s are available.

4.1.1.2 Postulation of design basis characteristics

Postulation of proper specifications for extreme weather conditions if not included in the original design basis.

The PSR identified the following as design basis assessments:-

Precipitation

Rainfall with a $10^{-4}y^{-1}$ return was considered to be 100mm over 1h and 215mm over 24 hours. These figures include a +5% adjustment to account for predicted effect of climate change.

Snowfall

Snowfall for a $10^{-4}y^{-1}$ return was assessed as 64.9cm (adjusted for climate change).

Low temperatures

For a $10^{-4}y^{-1}$ return the extreme low temperature was $-19^{\circ}C$ (adjusted for climate change).

High temperatures

For a $10^{-4}y^{-1}$ return the extreme high temperature was $35.2^{\circ}C$ (adjusted for climate change).

High Wind

For a $10^{-4}y^{-1}$ return the extreme high wind was 166mph.

Lightning

For a $10^{-4}y^{-1}$ return 6.1 strikes on the site as a whole is predicted and for the reactors it is 1.4.

4.1.1.3 Assessment of frequency

Assessment of the expected frequency of the originally postulated or the redefined design basis conditions.

The PSR considerations were based on a return frequency of 10^{-4} per annum which was derived from the Design Engineering Guidelines.

4.1.1.4 Potential combinations of weather conditions

Consideration of potential combination of weather conditions.

Precipitation

Extreme rainfall of 215mm in a day could result in localised flooding within the site if the storm drains failed, but it is not considered to threaten the passive safety of the core which is now isolated from the rest of the primary circuit. However if considered in conjunction with a high wind event (e.g.hurricane), or lightning, which resulted in damage to the reactor building fabric then ingress of water into the core during defuelling operations could arise.

Snow and ice

The PSR considered that snow and ice loading on power lines and icing of exposed insulators could lead to loss of power, but due to the passive nature of the core cooling no nuclear safety implications would arise. The PSR considered that a snow loading of 64.8cm was within the normal design margin for the reactor roofs. However as for precipitation, ingress of melted snow into the core could be postulated if high winds or lightning occurred and resulted in damage to the building fabric.

Low Temperatures

Low temperatures could increase the risk of damage to metal structures within the reactor buildings but the consequences are not considered to be significant. Existing site procedures require a risk assessment for reactor work if temperature is 5°C or less, and prohibits work if temperature reaches 0°C. Low temperatures in conjunction with heavy rain would lead to similar consequences as discussed for ice and snow, but again of minor significance now that the reactor is shutdown.

4.2 Evaluation of safety margins

4.2.1 Estimation of safety margin against extreme weather conditions

Analysis of potential impact of different extreme weather conditions to the reliable operation of the safety systems, which are essential for heat transfer from the reactor and the spent fuel to ultimate heat sink. Estimation of difference between the design basis conditions and the cliff edge type limits, i.e. limits that would seriously challenge the reliability of heat transfer.

Now that the Chapelcross reactors are cooled by natural circulation of air, there are no envisaged scenarios where extreme weather conditions could threaten the integrity of fuel in the reactors or ponds.

Extreme low temperatures could cause brittle failure of steel structures. However extreme conditions do not occur suddenly but are preceded by a period in which the potential hazard would become known so that actions would be taken to alleviate any potential fault conditions. Existing procedures (PIOI A119/02 and PIOI A138/35) define minimum temperatures below which lifting operations are prohibited in the Ponds and Reactor building respectively.

4.2.2 Potential need to increase robustness of the plant against extreme weather conditions

Consideration of measures, which could be envisaged to increase plant robustness against extreme weather conditions and would enhance plant safety.

Due to the negligible nuclear safety risk posed by extreme weather conditions at Chapelcross and by procedures already in place to mitigate the effects, it is not considered necessary to further enhance structures on site against weather induced hazards.

5 Loss of electrical power and loss of ultimate heat sink

5.1 Nuclear power reactors

For writing chapter 5, it is suggested that detailed systems information given in chapter 1.3. is used as reference and the emphasis is in consecutive measures that could be attempted to provide necessary power supply and decay heat removal from the reactor and from the spent fuel. Chapter 5 should focus on prevention of severe damage of the reactor and of the spent fuel, including all last resort means and evaluation of time available to prevent severe damage in various circumstances. As opposite, the chapter 6 should focus on mitigation, i.e. the actions to be taken after severe reactor or spent fuel damage as needed to prevent large radioactive releases. Main focus in chapter 6 should thus be in protection of containment integrity.

5.1.1 Loss of electrical power

5.1.1.1 Loss of off-site power

- 5.1.1.1.1 Design provisions taking into account this situation: back-up power sources provided, capacity and preparedness to take them in operation.

The closing of switch gear and emergency response arrangements (ECC) would initially be supported by battery systems located in the turbine hall and reactors. Emergency lighting within the buildings is provided by battery power which will have approximately a 2 hour lifetime sufficient to effect evacuation of personnel.

The emergency diesels will be manually brought into service by connection to the 415V distribution systems in either the turbine hall or the reactors, to support reactor functions such as dry air plant and instrumentation and also the Emergency Control Centre and Access Control Points. Each alternator would have sufficient diesel to support the site at full load for approximately 24h.

At least one of the mobile alternators is in a state of permanent readiness (Minimum Safety Related Plant) with SQEP personnel available on all shifts to effect connection to the distribution circuits. The assurance of readiness is supported by inclusion of the routine tests and checks in the PMS part 2.

- 5.1.1.1.2 Autonomy of the on-site power sources and provisions taken to prolong the time of on-site AC power supply.

The mobile alternators will function autonomously provided sufficient diesel fuel is available. As there are two units the site could be supported for a total of 48 hours at full load. Additional diesel supplies could be accessed from the locomotive or the boiler house. Off-site supplies would be sourced as a matter of urgency through local suppliers, garages, businesses or from local farms. Disruption to the local transport infrastructure may necessitate additional support from local authorities or Armed Forces as directed by the Emergency Response Teams.

5.1.1.2 Loss of off-site power and loss of the ordinary back-up AC power source

- 5.1.1.2.1 Design provisions taking into account this situation: diverse permanently installed AC power sources and/or means to timely provide other diverse AC power sources, capacity and preparedness to take them in operation.

There are no further provisions in place if the batteries and mobile diesels are out of commission.

The site has previously procured diesel alternators on a temporary basis from local contractors, but no reliance can be placed on this in an emergency.

The main impact of loss of power on the reactors would be shutdown of the dry air plants and cessation of the defuelling process.

The dry air plants are designed to ensure moisture levels within the core are maintained within temperature related limits (e.g <4500vpm at 7°C). Under existing site procedures the dry air units must be re-instated within 1 week (168h), although from experience it would take considerably longer for the ambient air conditions to challenge the 4500vpm limit. The dry air plants in an emergency could be run from the back up diesels, however in the complete absence of power they would not be a priority concern.

- 5.1.1.2.2 Battery capacity, duration and possibilities to recharge batteries.

The batteries supporting the Emergency Control Centre UPS system would last 3h without support from the mobile alternators.

5.1.1.3 Loss of off-site power and loss of the ordinary back-up AC power sources, and loss of permanently installed diverse back-up AC power sources

- 5.1.1.3.1 Battery capacity, duration and possibilities to recharge batteries in this situation

This question is not relevant to Chapelcross as the site has no provision for permanently installed back-up AC sources.

- 5.1.1.3.2 Actions foreseen to arrange exceptional AC power supply from transportable or dedicated off-site source

As for 5.1.1.3.1 above.

- 5.1.1.3.3 Competence of shift staff to make necessary electrical connections and time needed for those actions. Time needed by experts to make the necessary connections.

As for 5.1.1.3.1 above.

- 5.1.1.3.4 Time available to provide AC power and to restore core cooling before fuel damage: consideration of various examples of time delay from reactor shut down and loss of normal reactor core cooling condition (e.g., start of water loss from the primary circuit).

At the Chapelcross site the reactors are shutdown and there will be no requirements to restore core cooling. Current site procedures require the dry air plant to be reinstated within 168h (1 week) to ensure moisture control is re-established.

5.1.2 Measures which can be envisaged to increase robustness of the plant in case of loss of electrical power

Electrical supplies are no longer required for core cooling. In the event of prolonged loss of off-site and on-site AC power, mobile generators could be used to restore supplies to systems such as dry air systems long before any degradation of fuel takes place. No further measures identified.

5.1.3 Loss of the ultimate heat sink

5.1.3.1 Design provisions to prevent the loss of the primary ultimate heat sink

Design provisions to prevent the loss of the primary ultimate heat sink, such as alternative inlets for sea water or systems to protect main water inlet from blocking.

The Chapelcross reactors are passively cooled in (dried) air and so both the primary, and ultimate, heat sink is the atmosphere. Loss of atmosphere is incredible.

5.1.3.2 Effects of loss of the primary ultimate heat sink

Loss of the primary ultimate heat sink (e.g., loss of access to cooling water from the river, lake or sea, or loss of the main cooling tower).

5.1.3.2.1 Availability of an alternate heat sink

Not applicable – please refer to section 5.1.3.1.

5.1.3.2.2 Possible time constraints for availability of alternate heat sink and possibilities to increase the available time.

Not applicable – please refer to section 5.1.3.1.

5.1.3.3 Loss of the primary ultimate heat sink and the alternate heat sink

5.1.3.3.1 External actions foreseen to prevent fuel degradation.

Not applicable – please refer to section 5.1.3.1.

5.1.3.3.2 Time available to recover one of the lost heat sinks or to initiate external actions and to restore core cooling before fuel damage: consideration of situations with various time delays from reactor shut down to loss of normal reactor core cooling state (e.g., start of water loss from the primary circuit).

Not applicable – please refer to section 5.1.3.1.

5.1.3.4 Loss of the primary ultimate heat sink, combined with station black out (i.e. loss of off-site power and ordinary on-site back-up power source).

5.1.3.4.1 Time of autonomy of the site before start of water loss from the primary circuit starts.

Not applicable – please refer to section 5.1.3.1.

5.1.3.4.2 External actions foreseen to prevent fuel degradation.

Not applicable – see section 5.1.3.1.

5.1.4 Measures which can be envisaged to increase robustness of the plant in case of loss of ultimate heat sink

As discussed in section 5.1.3.1, it is not credible to lose the ultimate heat sink (the atmosphere) and therefore no further measures are required

5.2 Spent fuel storage pools

Where relevant, equivalent information is provided for the spent fuel storage pools as explained in chapter 5.1 for nuclear power reactors.

5.2.1 Loss of electrical power

The only impact on the ponds operations will be to halt decommissioning activities due to loss of lighting and monitoring equipment.

Currently one pond is used to store ILW and the second pond has been drained for decommissioning activities. The ponds have not been used to process spent fuel for over 5 years and the chiller unit has been disabled.

The ponds building can be supplied with back-up power from the mobile alternators via reactor 3.

5.2.2 Measures which can be envisaged to increase robustness of the plant in case of loss of electrical power

The ponds building can be supplied with back-up power from the mobile alternators via reactor 3.

5.2.3 Loss of the ultimate heat sink

Not applicable to Chapelcross as active cooling capacity within the ponds is not required.

5.2.4 Measures which can be envisaged to increase robustness of the plant in case of loss of ultimate heat sink

Following the Fukushima event a series of workshops have been held to consider the robustness of the site against internal and external hazards, and to look at the the site emergency preparedness arrangements. Some areas for consideration were identified and these are currently being assessed. The areas for consideration relevant to this section are given below:

Consideration CX 1: Consideration should be given to enhancing the resilience of spent fuel equipment to severe events.

6 Severe accident management

6.1 Organisation and arrangements of the licensee to manage accidents

Chapter 6.1 should cover organization and management measures for all type of accidents, starting from design basis accidents where the plant can be brought to safe shut down without any significant nuclear fuel damage and up to severe accidents involving core meltdown or damage of the spent nuclear fuel in the storage pool.

6.1.1 Organisation of the licensee to manage the accident

6.1.1.1 Staffing and shift management in normal operation

The standard shift team comprises of 20 personnel including a shift manager, a technical support engineer, two plant surveillance team leaders, and a lead fireman.

The shift team includes the fuel route team staffed by 8 personnel including the Duly Appointed Person (DAP). The shift flask handling building team consists of 5 personnel including a chargehand. CXPP shift team has a manning of 2. Additional to this complement there are a minimum of 3 Health Physics monitors on shift also.

The minimum shift team to support Emergency Team requirements is 14 (as defined in NP/SC 4883).

In event of an emergency the on site shift teams will assume the following responsibilities until relieved by the Emergency Response Team:

- Shift manager - Emergency Operations Controller
- Plant Surveillance Team Leader - Emergency Notification and Roll call officer
- Technical Support Engineer - Emergency Technical Support Engineer
- Fuel Route Supervisor (defuelling only) - Operations Support Team Member
- CXPP Surveillance Engineer - Access Control Point Controller
- Plant Surveillance Operator - Access Control Point Team Member
- CXPP Technical Assistant - Breathing Air(BA) Controller

6.1.1.2 Plans for strengthening the site organisation for accident management

The Emergency Notification Officer will initiate the emergency pagers of those personnel on call for each emergency duty as follows:

- Emergency Controller - Relieves Emergency Operations Controller
- Emergency Health Physicist
- Technical Support (Chemistry)
- Emergency Admin Officer
- On Call Shift Manager - Relieves Access Control Point Controller
- Emergency Reactor Physicist
- HP & S Team Leader
- Emergency Admin Support Officer
- Command & Control Board Writers
- Medical Staff

- On Call HP&S Monitors
- Operations Support Team as required

6.1.1.3 Measures taken to enable optimum intervention by personnel

On discovery of an anomalous situation, an initial assessment will be made by the Shift Manager/Emergency Operations Manager. If it is decided to enact the emergency arrangements, a muster alarm is sounded, and a public address announcement made. The Emergency Teams (and the Duty Emergency Controller) will be called to site and they will control the response to the situation from the Emergency Control Room (ECR).

All Emergency Response roles are clearly defined within the Emergency Handbook and are only allocated to appropriately trained personnel. Regular training exercises are undertaken and have observers who provide feedback on to the team on collective and individual performance.

The ECC and AECC are normally locked to ensure the equipment within the room is not tampered with, and the room is held in a state of readiness.

6.1.1.4 Use of off-site technical support for accident management

In the event of a site incident or off-site nuclear emergency being declared the Central Emergency Support Centre (CESC) is set up in Gloucestershire.

This dedicated facility is manned by a Controller, a Health Physicist and a Technical Officer each with a support team on a one-hour call out rota.

The remit of the CESC is to:

- (i) Relieve the affected station of the responsibility for liaison with outside bodies on off-site issues in as short a time as possible after an accident.
- (ii) Take over for the affected site at an early stage the task of directing the off-site monitoring teams and assessing their results.
- (iii) Provide the requisite technical advice on off-site issues to all stakeholders in the Strategy Coordination Centre and those agencies represented in the CESC.
- (iv) Provide regular authoritative company briefings for the media on all aspects of the emergency.
- (v) Co-ordinated advice and support from within the affected company and other parts of the nuclear industry to the affected station.
- (vi) Centrally manage the collation of all relevant information relating to the event (using appropriate means).

The CESC Controller has the full backing of the Company to take whatever steps are necessary, including using any resources required, to control the situation.

The Technical Support Team in the CESC has access to the Company Drawing Office so can obtain and print systems diagrams and a range of experts to help analyse the issues on-site and formulate recovery plans.

The CESC also has access to Procurement and the Supply Chain to obtain any goods or services required in the recovery.

The CESC manages the links to the local and national responding organisations.

The CESC takes over the management of the Off-site survey and the formulation of Company advice.

The CESC mobilises and coordinates the resources of the whole Company and cooperation from other nuclear companies.

6.1.1.5 Procedures, training and exercises.

The purpose of the Chapelcross Emergency Handbook is to describe the Emergency Arrangements at Chapelcross in accordance with site licence, statutory and mandatory requirements.

The document comprises two main parts, the **CHAPELCROSS EMERGENCY PLAN** which describes the general response arrangements and emergency management organisation for incidents and emergencies on the Chapelcross Nuclear Licensed Site, and the **CHAPELCROSS EMERGENCY HANDBOOK** which contains the detailed instructions and guidance for key personnel within the Emergency Management Organisation together with details of the response to emergency situations. The Handbook also describes reciprocal arrangements for support to or from other nuclear sites.

Chapelcross Emergency Plan and the Chapelcross Emergency Handbook reflect Magnox Company Standards which have been approved by the HSE and the ONR.

Chapelcross Emergency Management Arrangements are covered in the Chapelcross Site Management Arrangements.

The Site Event Reporting System (SERS) referred to in the Emergency Handbook is to be used in conjunction with the Company Standard 'Emergency Notification Arrangements'. Copies are held in the ECR, ECC and AECC.

Key Emergency Roles and Responsibilities defined in the above procedures have been allocated and are as shown in the Emergency Handbook.

Emergency Exercises are covered by a Work Instruction which reflects the relevant Company Standards.

Exercises:

The following emergency exercises are carried out annually.

1. 5x shift emergency exercises.
2. 1x Peer Assist exercise
3. 1x Level 1 exercise (ONR demonstration exercise)
4. 1x Security exercise.

On a 3 yearly basis:

1. 1x Level 2 exercise to demonstrate Local Authority Emergency Plans.
2. 1x Radiation Safety exercise to demonstrate Transport Emergency Plan.

The effects of extreme weather have been considered by the site and a number of procedures exist to define appropriate responses.

Existing Site Procedures

Existing site procedures

(i) Detail action required if heavy rain or high winds are experienced. For high winds a series of defined actions are triggered by specified wind speeds (i.e. 30knots, 40knots, and 55knots) with tannoy announcements for site communication. As wind speeds reduce inspection and clean up activities are also documented.

(ii) Detail actions to be taken in the event of Extreme Cold/Freezing Conditions. This includes priority road clearing activities with site snow plough and gritting equipment, grit stock levels, plant inspections and equipment checks to heaters to minimise impact of cold conditions.

(iii) Give guidance covering priorities regarding clearance of site roads for emergency vehicles (covered in detail in ODPI P48). Also covers arrangements for site drivers to ferry key staff to and from work in event of heavy snowfalls using 4 wheel drive vehicles and vehicles fitted with snow chains.

(iv) Include Symptom Based Emergency Response Guidelines (SBERGs) provide advice to the operator on best course of action to take in beyond design basis accidents to prevent uncontrolled release of radioactivity and prevent damage that may lead to fuel failure or economic damage.

(v) Include Severe Accident Guidelines for Chapelcross.

6.1.2 Possibility to use existing equipment

- 6.1.2.1 Provisions to use mobile devices (availability of such devices, time to bring them on site and put them in operation)

The Company shares a Beyond Design Basis Accident Container set in a central location in the UK that can be transported to any affected site. These containers are equipped with Command and Control, fire fighting, reactor cooling and contamination control materials.

6.1.2.2 Provisions for and management of supplies (fuel for diesel generators, water, etc.)

Due to the passive nature of the reactor cooling arrangements, no specific provisions are made.

In an emergency, procurement of supplies would be dealt with by the CESC.

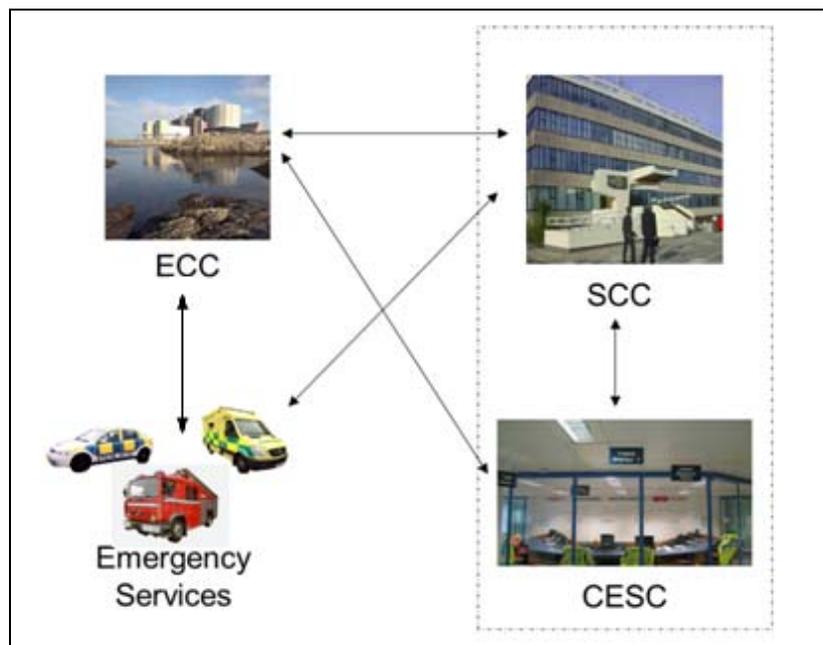
6.1.2.3 Management of radioactive releases, provisions to limit them

In the event of a radiological release the EPGMS equipment would give an initial indication of the scale of the incident. This could then be backed up by the off-site emergency vehicles monitoring the local environment to allow a more detailed assessment of the impact. Information gathered will be used by the emergency response team to decide on the appropriate measures to be taken to limit the impact on the local population.

In the event that pond shielding is lost the option exists to refill the pond to provide shielding or minimise airborne contamination.

6.1.2.4 Communication and information systems (internal and external).

In the event of an accident or natural disaster at a power station there is a need to be able to promulgate an alert and then to pass information into and out of the site. Particularly important communications paths are those between the site, the Strategic Coordinating Centre (SCC), the Central Emergency Support Centre (CESC) and the responding emergency services (see diagram).



Magnox Communications Systems

The Magnox telephone system is designed to be resilient and function through any single point failure. Chapelcross has two telephone exchanges physically separated and connected to the Public Switched Telephone network (PSTN) via diverse routes². Phones in the key response centres are divided between the two exchanges so that failure of an exchange will not leave the room without at least some working phones. The telephone exchanges are connected to robust electrical supplies and have battery backup with a design period of not less than 300 minutes.

The exchanges are connected to the PSTN using a Secure+ link which provides each exchange with dual separated routes to the public network. In addition at least one phone is connected directly to the public system without passing through the Company exchanges.

A link is provided to the Government Telephone Network (GTN).

The Magnox Wide Area Network (WAN) provides data and voice links between the sites and is designed with a degree of resilience.

Communications in a Crisis: Declaration and Promulgation

An affected site would declare a Site Incident or Off-site Nuclear Emergency and promulgates the alert using the Site Event Reporting System (SERS). SERS is a resilient system based on two servers at two different locations within Magnox, giving a replicated service with no single point of failure.

SERS alerts a number of internal personnel and external personnel using telephones on Dial and Deliver, voice mail systems and pagers. Backup systems exist in the event of any component of the system.

The minimum infrastructure required to alert company responders is a single working phone on site, the PSTN and the pager system to be running.

Alerting of other organisations requires a functioning phone system at both ends.

Receiving the alert, which contains minimal information, is sufficient to trigger a multi-agency response to an Off-site Nuclear Emergency.

Communications in a Crisis: Site Communications with Emergency Services

The sites need to communicate with the emergency services to:

- Promulgate the alert
- Explain the severity and urgency of the situation

² BT offer three types of links from site to the national network infrastructure.

Standard	Single link provided
Secure	Dual fibre routed from a single POP. (Point of Presence)
Secure+	Dual fibre routed from separate POPs and separation of routes guaranteed end to end (unless specified during survey)

- To define the resources needed

There are a number of ways in which the site can communicate with the police and other emergency services:

- Emergency Services are alerted and informed using the 999 system using the Magnox telephone system and the PSTN.
- Further information is provided by FAX.
- The Emergency Services each send an Officer to the affected site's ECC. These officers will be able to communicate with their Headquarters by:
 - Telephone
 - Fax
 - Service mobile phone
 - Service Airwave radio
- There are many mobile phones on each Magnox site which provide another line of communications should it be needed.

Once the Emergency Services are deployed they can use their own communications infrastructure to communicate with their co-ordination functions and across the responding forces.

Key mobile phones used within Magnox are registered on the Mobile Telephone Privileged Access System (MTPAS)

Communications in a Crisis: CESC to/from Site

The CESC and site need to be able to communicate to:

- Raise the alarm.
- Discuss the situation.
- Discuss the recovery plans and equipment/supplies needs.
- Report progress and issues when recovery plans are implemented.

The CESC voice services consist of the following infrastructure and features:

The CESC provides telephones for each agreed CESC staff member. 50% of the telephones will be served from each of two PABXs.

The two PABXs are located in separate buildings, with separate batteries and power supplies. At least one of the PABXs is generator backed as well as the batteries. Batteries will provide at least 6hr backup.

Cabling between the PABXs and the CESC telephones follow separate routes as far as practicable. Separate routes are provided through the EDF network between the EDF-Magnox Ltd gateways and the PBXs serving the CESC, such that any single fault will not affect more than 50% of the connections.

CESSC DDI service is provided to CESC telephones which are separate from the normal site DDT service, both in numbering range, lines and carrier (PTOs). Each PABX has CESC DDI service, arranged such that if one PABX is faulty, service will continue via the other PABX.

CESSC telephones will have outgoing PSTN access to at least two carriers (PTOs).

In extremis the Airwave system NIAS (Nuclear Industry Airwave Service) can be used to communicate between the sites and the CESC. This is a national resilient system. In this system the voice capability is resilient against failures in the Company network although such failures can defeat the data pathways.

Communications with off-site survey vehicles

The Airwave system (NIAS) provides the means for communication with the mobile survey vehicles deployed in an emergency situation. Failure of the WAN would not affect voice communication between survey vehicles, the CESC and the affected site. Data communication would however be lost and it would be necessary to relay results back by voice. This would result in some inconvenience in plotting the survey data but would not present a significant nuclear safety-related issue.

Communications: CESC to/from SCC

The CESC needs to be able to communicate with the SCC to:

- To communicate and discuss the situation
- To communicate the Company's view of off-site countermeasures required.

Key links are telephone (Voice and FAX)

Voice services to Strategic Coordinating Centres (SCCs) are provided under contract. They comprise:

- The means to enable six simultaneous voice or FAX telephone calls to be established to or from the contractor's telephone network without using the PSTN, consisting of two routes, each capable of three simultaneous calls.
- At the contractor's end of each route, the two routes terminate at separate private network nodes.
- Each terminating network node is not be on a site where the equipment, connectivity or access can be affected by a nuclear incident.
- At the SCC end of each route, the two routes are terminated on separate (Multiplexor) equipment. The equipment is located in separate rooms if possible. The equipment has separate power supplies as far as is practicable. The power supplies are taken from maintained (no break) supplies where locally available.
- If two SCC PABXs are available, one route is connected to each, approx. 50% of the telephones to each.
- Two routes are provided through the contractor's network between the contractor's end of each SCC route and the PBXs serving the CESC, such that any single fault on the contractor's network will not affect more than 3 voice channels between the CESC and any SCC.

In addition the PSTN can be used if available.

In addition mobile phones can be used if available.

In addition the SCCs are built in Police facilities and can benefit from the Police Service's communications systems.

Company communications with other organisations

The SCC and CESC are both communications hubs in which information is shared between the Company and external organisations.

In addition the Company operates the Tiims (The Incident Information Management System) system which is available to key external agencies.

Tiims is a Lotus Notes based information system, supporting data entry, validation and action tracking. The system may be used remotely between the CESC, SCCs, HPA (Health Protection Agency), FSA (Food Standards Agency), DfT (Dept. for Transport) and the DECC (Dept. of Energy and Climate Change) to display key information relating to a nuclear emergency.

The Tiims service is provided on workstations located at the CESC, SCCs and various remote locations e.g. DECC, HPA DfT, Food Standards Agency (FSA.)

Tiims runs on a dedicated server with a backup available.

The following is provided at each SCC, to support delivery of the Tiims service:

- A basic rate ISDN line.
- A router.
- A local area network
- Two workstations
- Provision on the LAN for a further two workstations at the shared SCCs
- Provision on the LAN for four workstations at the Magnox Ltd SCCs.
- A fall back communications channel if the ISDN is unavailable.
- UPS.

Two mobile SCC workstations are provided as central equipment, which will be taken to SCCs as required.

ISDN connectivity is provided at the CESC, to support delivery of the Tiims service to any one of the SCCs, along with a fallback communications channel if the ISDN is unavailable.

ONR, DECC, HPA, DfT, FSA have workstations which connect via ISDN.

Communications between the off-site responders

The Government has established a policy to improve the resilience of Critical National Infrastructure (CNI) to disruption. Details are summarised below:

Critical National Infrastructure (CNI)

The Government defines CNI as: “Those infrastructure assets (physical or electronic) that are vital to the continued delivery and integrity of the essential services upon which the UK relies, the loss or compromise of which would lead to severe economic or social consequences or to loss of life”. Communications is one of nine sectors considered. Within the communications sector are four strands:

Strand 1. Working with providers and responders to enhance the resilience of everyday commercially available telecommunications.

Strand 2. Improving the management, takeup and resilience of privileged telecommunications schemes that are only accessible to emergency responders.

Strand 3. Delivering a High Integrity Telecommunications System (HITS) providing connectivity and services between key responder sites at the national, regional and local level.

Strand 4. Delivering a means for securely sharing information between all local regional and national responders both in preparing for and in response to an emergency (National Resilience Extranet).

6.1.3 Evaluation of factors that may impede accident management and respective contingencies

6.1.3.1 Extensive destruction of infrastructure or flooding around the installation that hinders access to the site

The inland and elevated location of the Chapelcross site offers a number of natural advantages with regard to access and flood resistance in the event of local infrastructure destruction.

Firstly the site is approximately 5km from the sea at an elevation on 74m above sea level and is situated on a sloping site.

The site may be accessed from different roads offering four diverse approach routes. The site is also close to the main north-south motorway (M74) to facilitate emergency support if required. While support from the low lying local population centres (Carlisle and Annan) may be disrupted support could be provided from Dumfries, Lockerbie and ultimately Glasgow using upland access routes.

The site will have sufficient manning to cope with the initial impact of any emergency with a normal shift roster of 20 personnel and a minimum emergency team requirement of 14. The shift managers are trained to assume full Emergency Control role while awaiting relief by the Emergency Response

Teams. In an ongoing emergency situation relief staff would be called in as and when required.

6.1.3.2 Loss of communication facilities / systems

The Company has robust communications systems featuring diversity and redundancy, particularly at operating sites. These include:

- A resilient Company Wide Area Network
- For operating sites – diverse routes to the outside world communications cloud.
- Telephones that are independent of the Company exchanges with direct (copper) links to the PSTN.
- The Nuclear Industry Airwave Service, designed to allow communication with off-site survey vehicles, can be used to make phone calls independent of the local PSTN.

A total failure is highly unlikely.

Potential Impact of widespread disruption and mitigation

- Loss of mains electricity for prolonged period
 - Should be able to promulgate alert before the battery backup fails.
 - Should have several hours of battery time to communicate initial information and to engineer communications routes
- Loss of masts for mobile phones and Airwave
 - Can use voice function within airwave if sufficient infrastructure exists. Have mobile phones on different services (accidental rather than be design at the moment), can record readings and report back using land-land phones or by returning to site.
- Loss of telephone exchanges (Direct loss or loss of power)
 - Use of mobile phones (on MTPAS), NIAS radio, direct line or runners
- Cabling damage
 - Real efforts have been made to avoid common mode failure with regard to cable routes for WAN and phone calls.
- Damage to PABXs
 - There are two of these on operating sites with the design intent that it is unlikely that they would both be damaged in any reasonably foreseeable event.

6.1.3.3 Impairment of work performance due to high local dose rates, radioactive contamination and destruction of some facilities on site

In all exposure conditions including accident response, doses to personnel should be below dose limits (normally 20 mSv whole body dose) and must be As Low as Reasonably Practicable (ALARP). In the event of a major accident at a nuclear site the higher REPPiR Emergency Exposures can be applied to

informed volunteers. The role of the Health Physicist in the Emergency Control Centre (ECC) is to ensure the safety of all people on site.

Staff that are not responding to an accident will be subject to controls based on dose rate, airborne contamination levels and other hazards, and may be evacuated from the site.

The ECC is positioned to minimise the likelihood that it would be damaged in an accident or affected by radiation. It would be subject to tenability checks, the Initial Control Dose limit being 10 mSv over the first 10 hours. After this period the situation would be reassessed in the light of the radiological conditions, availability of replacement staff, etc. Arrangements are in place to transfer the functions of the ECC to the on-site alternative ECC should the primary facility be declared untenable, including destruction and blocked access.

On-site survey and emergency team staff controlled from the Access Control Point (ACP) are subject to the normal dose limits but in the event of a major accident the higher REPPiR Emergency Exposures (whole body doses of 100 mSv for operations and 500 mSv for life saving) can be applied to informed volunteers. Health Physics monitoring provides information on the local dose rates allowing response teams to ensure their doses are minimised and Electronic Personal Dosimeters are used to monitor doses and enforce dose limits. If necessary, the on-site Alternative ACP, or other suitable facility, would be used.

Training is given on the use of appropriate Personal Protective Equipment, including breathing apparatus, and undressing/ decontamination processes, and use of these would not prevent appropriate remedial work being undertaken.

In some extreme instances high radiation levels could make access to the damage scene unachievable. If this were the case then remote access or the installation of the appropriate level of shielding would be required. If radiation levels remain high then working time would be limited, which could impair the recovery operation particularly if the operations required are time consuming. Under conditions of high local dose rates, contamination and destruction of some facilities the Company would be relying on the site Command and Control structures to manage the event making an accurate assessment of the situation and best use of available resource.

6.1.3.4 Impact on the accessibility and habitability of the main and secondary control rooms, measures to be taken to avoid or manage this situation

Each of the four Chapelcross reactors are provided with dedicated main reactor control rooms but no secondary control room. However if these rooms become untenable, reactor monitoring can still be carried out from the ECC (turbine hall) or the AECC (training centre).

The site roll call and site sirens are carried out from the Electrical Control Room which is housed in the turbine hall adjacent to the ECC.

- 6.1.3.5 Impact on the different premises used by the crisis teams or for which access would be necessary for management of the accident.

Key emergency response centres on site are the Emergency Control Centre (ECC) and Access Control Point (ACP). The Chapelcross site has fully functional alternative facilities should the primary facility be unavailable.

The ECC (and Alternative ECC) contain the main communication links to coordinate incident response. The ACP (and Alternative ACP) is equipped with Breathing Apparatus (BA) sets and protective clothing stores to support incident response as well as decontamination facilities for returning response teams.

- 6.1.3.6 Feasibility and effectiveness of accident management measures under the conditions of external hazards (earthquakes, floods)

The accident management measures are intended to be flexible. Identified personnel have high levels of authority to utilise any resources available and technical advice is available from off-site facilities.

- 6.1.3.7 Unavailability of power supply

If power was lost to the site, the UPS and battery systems would support the emergency control arrangements. Diesel alternators would then be used as described previously with additional diesel supplies accessed as necessary either from on-site or off-site sources. Communications with the off-site emergency vehicles can be maintained by use of mobile phones which are held on the vehicles for this purpose.

- 6.1.3.8 Potential failure of instrumentation

Key reactor parameters are displayed in the Emergency Control Rooms. Alternative monitoring systems are available should be primary systems fail. Reactor temperatures could be taken using portable voltmeters and the existing Manual Measuring System equipment.

- 6.1.3.9 Potential effects from the other neighbouring installations at site.

Chapelcross has no neighbouring site and is therefore this question is not applicable.

6.1.4 Measures which can be envisaged to enhance accident management capabilities

Following the Fukushima event a series of workshops have been held to consider the robustness of the site against internal and external hazards, and to look at the site emergency preparedness arrangements. Some areas for consideration were identified and these are currently being assessed. The areas for consideration relevant to this section are given below:

Consideration CX 2: Consideration should be given to enhancing the availability of beyond design basis equipment
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Consideration CX 3: Consideration should be given to providing further equipment to facilitate operator access around the Site

Consideration CX 4: Consideration should be given to enhancing on site arrangements for command, control and communications.

Consideration CX 5: Consideration should be given to updating and enhancing severe accident management guidance.

6.2 Maintaining the containment integrity after occurrence of significant fuel damage (up to core meltdown) in the reactor core

6.2.1 Elimination of fuel damage / meltdown in high pressure

6.2.1.1 Design provisions

Chapelcross reactors are de-pressurised, shutdown and partially defuelled, therefore question is not applicable.

6.2.1.2 Operational provisions

As for 6.2.1.1.

6.2.2 Management of hydrogen risks inside the containment

6.2.2.1 Design provisions, including consideration of adequacy in view of hydrogen production rate and amount

The Chapelcross reactors are currently at ambient temperature and reactor environment is controlled by application of dry air to minimise moisture levels such that hydrogen cannot be produced in any significant quantities.

6.2.2.2 Operational provisions

See section 6.2.2.1. above

6.2.3 Prevention of overpressure of the containment

6.2.3.1 Design provisions, including means to restrict radioactive releases if prevention of overpressure requires steam / gas relief from containment

Not applicable to the Chapelcross site as the reactors are shutdown, the heat exchangers have been drained and the reactor environment is protected by pressure relief valves.

6.2.3.2 Operational and organisational provisions

Pressure within the reactors continues to be monitored and trended. The dry air plant would trip on pressures of 2.8psig and the pressure relief valves are part of the maintenance schedule.

6.2.4 Prevention of re-criticality

6.2.4.1 Design provisions

The reactors are now shutdown, partially defuelled and passive measures are in place to ensure that re-criticality is incredible. (refer to section 1.3.1).

6.2.4.2 Operational provisions

The protection against re-criticality is based on passive systems.

6.2.5 Prevention of base-mat melt through

6.2.5.1 Potential design arrangements for retention of the corium in the pressure vessel

Since reactors at Chapelcross are permanently shutdown and passively cooled the design basis no longer considers fuel melt or fire to be credible, so prevention measures are not required, nor provided.

6.2.5.2 Potential arrangements to cool the corium inside the containment after reactor pressure vessel rupture

Not applicable see section 6.2.5.1 above.

6.2.5.3 Cliff edge effects related to time delay between reactor shutdown and core meltdown

Not applicable see section 6.2.5.1 above.

6.2.6 Need for and supply of electrical AC and DC power and compressed air to equipment used for protecting containment integrity

6.2.6.1 Design provisions

AC and DC power and compressed air are not required for protecting reactor containment integrity at Chapelcross.

6.2.6.2 Operational provisions

Not applicable –see section 6.2.6.1 above.

6.2.7 Measuring and control instrumentation needed for protecting containment integrity

There are no instrumentation requirements for protecting containment integrity. However core temperatures and pressures are routinely monitored by the Reactor

Data Logging System, which can be backed up by manual measurement using analogue pressure gauges and temperature measurement using portable voltmeters.

6.2.8 Measures which can be envisaged to enhance capability to maintain containment integrity after occurrence of severe fuel damage

None identified.

6.3 Accident management measures to restrict the radioactive releases

6.3.1 Radioactive releases after loss of containment integrity

6.3.1.1 Design provisions

As the reactors are permanently shutdown with passive cooling in place a loss of containment from the primary circuit would result in a release of contaminated air with very low radiological consequences. The release from the primary circuit would be contained initially by the reactor void (which vents to atmosphere) or by the reactor building itself. Damage to fuel within the reactors is now considered to be not credible.

6.3.1.2 Operational provisions

In event of a radioactive release the first operational provision would be to declare a Site Incident or Off-Site Nuclear Emergency and set up the Emergency Control Room.

The scale and direction of the release may then be established by local monitoring or by the Emergency Plume Gamma Monitoring System and the Emergency response vehicles if an off-site release is suspected.

Chapelcross Emergency Handbook Section 13 (Emergency Procedures-Emergency Damage Repair Section) describes a range of techniques available to the site to effect repairs to containment breaches in the pressure circuit.

6.3.2 Accident management after uncovering of the top of fuel in the fuel pool

This section is not relevant to the Chapelcross site as the cooling ponds are no longer used to store fuel.

6.3.2.1 Hydrogen management

Hydrogen generation is not considered a significant issue as fuel is no longer stored in the ponds..

6.3.2.2 Providing adequate shielding against radiation

For Chapelcross, pond 2 contains an inventory of ILW. In event of a loss of shielding the pond level could be topped up from the adjacent water hydrants. Water hoses are maintained on site to support this option.

6.3.2.3 Restricting releases after severe damage of spent fuel in the fuel storage pools

Fuel has been removed from the ponds and hence this situation will not arise.

6.3.2.4 Instrumentation needed to monitor the spent fuel state and to manage the accident

None required as there is no fuel present.

6.3.2.5 Availability and habitability of the control room

There is no control room within the ponds building.

6.3.3 Measures which can be envisaged to enhance capability to restrict radioactive releases

For the site in its current passively safe condition no new measures have been identified.

For release from a reactor a number of operational steps could be taken such as shutdown of the dry air plant and closure of vent valves. For the ponds, options exist to refill the pond with water to minimise airborne contamination.

However the most effective measures are considered to be completion of the defuelling programme and decommissioning of the ponds which is currently underway.

7 Glossary

AC	Alternating Current
AACP	Alternative Access Control Point
ACP	Access Control Point
AECC	Alternative Emergency Control Centre
ALARP	As Low as Reasonably Practicable
BBSD	Boron Balls Shutdown Devices
BA	Breathing Air
CECC	Central Emergency Support Centre
CNI	Critical National Infrastructure
CXPP	Chapelcross Processing Plant
DAP	Duly Appointed Person
DBE	Design Basis Earthquake
DBF	Design Basis Flood
DC	Direct Current
DCIC	Ductile Cast Iron Container
DDI	Direct Dial Identifier
DECC	Department of Energy and Climate Change
DfT	Department for Transport
DPS	Data Processing System
ECC	Emergency Control Centre
EOS	Electrical Overlay System
EPGMS	Emergency Plume Gamma Monitoring System
FSA	Food Standards Agency
HPA	Health Protection Agency
IFE	Irradiated Fuel Element
ILW	Intermediate Level Waste
ISDN	Integrated Services Digital Network
LLW	Low Level Waste
MPLS	Multiprotocol Label Switching
MTPAS	Mobile Telephone Privileged Access System
NIAS	Nuclear Industry Airwave Service
OD	Ordnance Datum (Mean Sea Level in Newlyn in Cornwall UK 1915 - 1921)
ONR	Office for Nuclear Regulation
PABX	Private Automated Branch Exchange
PAX	Private Automated Exchange
PPFHA	Peak Free-Field Horizontal Acceleration

PGA	Peak Ground Acceleration
PML	Principia Mechanic Limited
PMS	Plant Maintenance Schedule
PSA	Probabilistic Safety Analysis
PSR	Periodic Safety Review
PSTN	Public Switched Telephone Network
PTO	Public Telecommunications Operator
REIC	Remote Emergency Indication Centre
REPPIR	Radiation (Emergency Preparedness and Public Information) Regulations
SBERGs	Symptom Based Emergency Response Guidelines
SCC	Strategic Coordinating Centre
SERS	Site Event Reporting System
SP	Scottish Power
SSC	Systems, Structures and Components
TiiMS	The Incident Information Management System
UHS	Ultimate Heat Sink
UPS	Uninterruptible Power Supply
VRLA	Valve Regulated Lead Acid
WAN	Wide Area Network

8 Table 1: Considerations Identified for Chapelcross Site

Ref	Section No.	Consideration
CX 1	5.2.4	Consideration should be given to enhancing the resilience of spent fuel equipment to severe events.
CX 2	6.1.4	Consideration should be given to enhancing the availability of beyond design basis equipment
CX 3	6.1.4	Consideration should be given to providing further equipment to facilitate operator access around the Site
CX 4	6.1.4	Consideration should be given to enhancing on site arrangements for command, control and communications
CX5	6.1.4	Consideration should be given to updating and enhancing severe accident management guidance