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REGULATORY OBSERVATION Resolution Plan	
RO Unique No.:	RO-UKHPR1000-0056
RO Title:	Fuel Route Safety Case
Technical Area(s)	Cross-cutting
Revision:	0
Overall RO Closure Date (Planned):	2021-05-31
Linked RQ(s)	
Linked RO(s)	RO-UKHPR1000-0014
Related Technical Area(s)	Civil Engineering, Control & Instrumentation, Conventional Health & Safety, Fault Studies, Fuel & Core, Human Factors, Mechanical Engineering, Probabilistic Safety Analysis, Radiological Protection, RadWaste, Decommissioning & Spent Fuel Management
Other Related Documentation	

Scope of Work

Background

After reviewing the work carried out by the RP to address the gaps identified in RO-UKHPR1000-0014, ONR judges that the radiological risks to workers from a dropped fuel assembly or a dropped spent fuel transfer cask have not been shown to be reduced ALARP. Therefore, ONR raised a Regulatory Observation (RO-UKHPR1000-0056) titled "Fuel Route Safety Case" that expects the RP to provide a suitable and sufficient safety case for handling of spent fuel and handling of spent fuel casks within the Fuel Building (BFX).

RO-UKHPR1000-0056 contains the following actions:

- RO-UKHPR1000-0056.A1 – Handling of Spent Nuclear Fuel
- RO-UKHPR1000-0056.A2 – Handling of Spent Fuel Casks

Scope of work

RO-UKHPR1000-0056 focuses on the safety demonstration of the design of fuel route, especially for Fuel Handling and Storage System (PMC [FHSS]) and Spent Fuel Interim Storage (SFIS) within BFX.

For the PMC [FHSS], the scope partially overlaps between RO-UK HPR1000-0014 and this RO. Under this RO, the RP will provide a suitable and sufficient safety case for the handling of spent fuel by the Spent Fuel Pool Crane (SFPC). Combined with the information provided to resolve RO-UK HPR1000-0014, this should demonstrate that the relevant

risks from spent fuel handling within BFX have been reduced to ALARP.

For the SFIS which is part of the whole fuel route within the nuclear power plant and starts from the transferring of spent fuel out of the spent fuel pool and finishes with the retrieval and repackaging of spent fuel for final disposal, the safety case related to lifting/handling operations in BFX is being provided as part of the resolution plan for RO-UK HPR1000-0014. Apart from the lifting/handling operations in BFX, the ALARP demonstration for SFIS operations is covered by the work to resolve RO-UK HPR1000-0050.

The linkage to the information presented in RO-UK HPR1000-0014 and RO-UK HPR1000-0050 will be presented in this RO but detailed information will not be duplicated. To resolve RO-UK HPR1000-0056, the RP will therefore provide complementary safety case for the handling of spent fuel and spent fuel casks within the BFX which demonstrate that the relevant risks from spent fuel and spent fuel cask handling have been reduced to ALARP.

This resolution plan describes the Requesting Parties current plan to satisfy the concerns presented in RO-UK HPR1000-0056. It contains the general strategy, planned activities, submissions, timescales, as well as resources assignment.

Deliverable Description

The main actions required to resolve this RO are described as follows.

RO-UKHPR1000-0056.A1 – Handling of Spent Nuclear Fuel

Actions requested by the Regulator as stated in the RO:

- *Provide application of the RP's categorisation and classification methodology.*
- *Provide suitable and sufficient engineering substantiation to demonstrate that the SFPC meets the requirements for that classification of SSC.*

Resolution Plan:

1) Introduce the fuel handling process and operations. The latest fuel handling process and operations after the design modification based on 6 gaps identified in the RO-UKHPR1000-0014 will be presented in the updated version of *Fuel Handling Process and Operations*, Reference [1]. The spent fuel handling operations in relation to SFPC will be introduced in this document. This document is based on Design Reference (DR) Version 2.2, including the layout drawing of fuel handling and storage system, system design manual, technical specification for the spent fuel pool crane, etc.
2) Re-evaluate PIEs. The PIE identification will focus on fuel handling operations by SFPC within the BFX. The PIEs will be identified through the process presented below, which is presented in *PIE List of UK HPR1000 of Internal Event (Except for Loss of Support System)*, Reference [2].
   - Identification of fuel route steps;
   - Identification of possible failures in each step of fuel route;
   - Qualitative consequences analysis. For each failure, qualitative consequence analysis will be performed;
   - Fuel route PIE. Failures, except for those excluded by qualitative analysis, will be considered as fuel

route PIEs.

The unmitigated consequences analysis for the fuel route PIEs identified is presented in *On-site Radiological Consequence Evaluation for Fuel Route PIE*, Reference [3].

The identification process of fuel route PIEs will be reviewed based on the design modifications to the BFX included in DR Version 2.2. The Reference [2] will be updated if new PIEs are identified.

3) Identify risk and evaluate consequences. Based on the latest design, carry out hazards identification and consequence analysis, including hazards identification related to spent fuel handling operations within BFX and consequence analysis of the identified hazards. The evaluation will focus on the fault studies, internal hazards (e.g. dropped load), radiological consequence and conventional health and safety.

a) For the fault studies and radiological consequence, the bounding case from PIE grouping for the fuel handling accidents is "drop of fuel assembly". The radiological consequences for this accident have been evaluated and presented in the following reports:

- *Dropping of Fuel Assembly*, Reference [4], calculation of source term;
- *Worker Dose Assessment for Representative Design Basis Accidents*, Reference [5], calculation of dose exposure to on-site workers;
- *On-site (MCR) Radiological Consequences analysis for Representative DBC Accidents of UK HPR1000*, Reference [6], calculation of dose exposure to MCR workers;
- *Off-site Radiological Consequences analysis for Representative DBC Accidents of UK HPR1000*, Reference [7], radiological consequences analysis for off-site people.

All the above documents have already been submitted based on DR version 2.1, and they will be reviewed based on the design modifications to the BFX included in DR Version 2.2. For any newly identified DBC, radiological consequence evaluation will be carried out, and the relevant reports will be updated if necessary.

b) For the internal hazards, drop of spent fuel is included in the dropped load analysis. The radioactive releases from the damaged spent fuel assembly is considered in the fault studies of fuel handling accident; Other risk is the potential damage of spent fuel pool integrity from the drop of fuel assembly, and this is presented in *Dropped Loads Safety Assessment Report for Fuel Building*, Reference [8] and *Impact Analysis of Design Modification on Civil Engineering*, Reference [9].

c) For the conventional health and safety, the risks have been recorded in the *PMC Conventional Health and Safety Design Risk Register*, reference [10]. The fuel handling process and operations will be reviewed based on the design modifications included in DR Version 2.2, and the DRR report will be updated if additional risks are identified.

4) Carry out optioneering. If gaps or shortfalls are identified in the previous steps, optioneering should be carried out to select the best option which can reduce the overall risks to be ALARP, e.g. the type of SFPC including overhead crane and gantry crane, mechanical countermeasures or interlocks. Then implement the design improvement at a concept design level if necessary according to the result of optioneering. A comprehensive impact analysis should be carried out by all relevant disciplines and topic areas. This process will be addressed in the updated report *ALARP Assessment of the BFX Cranes Arrangements*, Reference [11]. Other impacted documents will also be updated accordingly before April 30th, 2021.

5) Classify the components of SFPC. Based on the crane type determined in step 4, identify the safety functions

relevant to faults or hazards and categorise them, then classify the components of SFPC based on the safety measures. According to the categorisation and classification methodology of cranes used in the UK HPR1000, the flow diagram of classification is shown in Figure 1. The classification methodology is presented in *Classification of the Typical Cranes*, reference [12]. The SFPC will be added into the typical cranes to show the whole classification process.

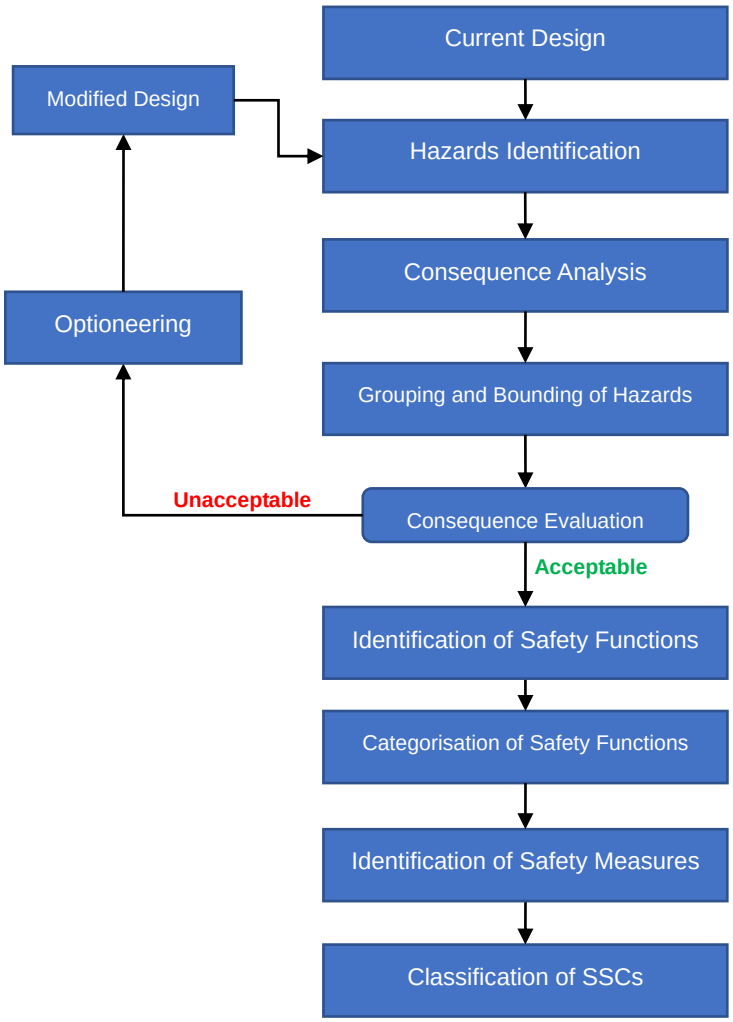

Figure 1 Flow Diagram of Crane Classification

6) Review the requirement. Review the design of SFPC to check whether all the requirements given in *Technical Specification for Nuclear Lifting and Handling Equipment*, Reference [13], for that classification determined in step 5 have been met. If not, the *Technical Specification for Spent Fuel Pool Crane*, Reference [14], should be updated to include the missing engineering measures.

Deliverables (reports):

No.	Deliverable	Type	Schedule
1	Fuel Handling Process and Operations	Update	31/12/2020
2	PIE List of UK HPR1000 of Internal Event (Except for Loss of Support	Update if necessary	08/01/2021

	System)		
	On-site Radiological Consequence Evaluation for Fuel Route PIE	Update if necessary	24/12/2020
3	Dropping of Fuel Assembly	Update	15/01/2021
	Worker Dose Assessment for Representative Design Basis Accidents	Update if necessary	15/01/2021
	On-site (MCR) Radiological Consequences analysis for Representative DBC Accidents of UK HPR1000	Update if necessary	15/01/2021
	Off-site Radiological Consequences analysis for Representative DBC Accidents of UK HPR1000	Update if necessary	15/01/2021
	Dropped Loads Safety Assessment Report for Fuel Building	Update if necessary	15/01/2021
	Impact Analysis of Design Modification on Civil Engineering	Update if necessary	15/01/2021
	PMC Conventional Health and Safety Design Risk Register	Update if necessary	15/01/2021
4	ALARP Assessment of the BFX Cranes Arrangements	Update	30/01/2021
5	Classification of the Typical Cranes	Update	30/01/2021
6	Technical Specification for Nuclear Lifting and Handling Equipment	Update if necessary	30/01/2021
	Technical Specification for Spent Fuel Pool Crane	Update if necessary	30/01/2021

Resources: CGN Mechanical Engineering (ME) team, fault studies team, internal hazard team, radiological protection, environmental, human factor team, layout team, CH&S and the UK TSC.

RO-UKHPR1000-0056.A2 – Handling of Spent Fuel Casks

Actions requested by the Regulator as stated in the RO:

- *Provide a suitable and sufficient safety case for the handling of spent fuel casks within the BFX to demonstrate that the relevant risks have been reduced to ALARP*

Resolution Plan:

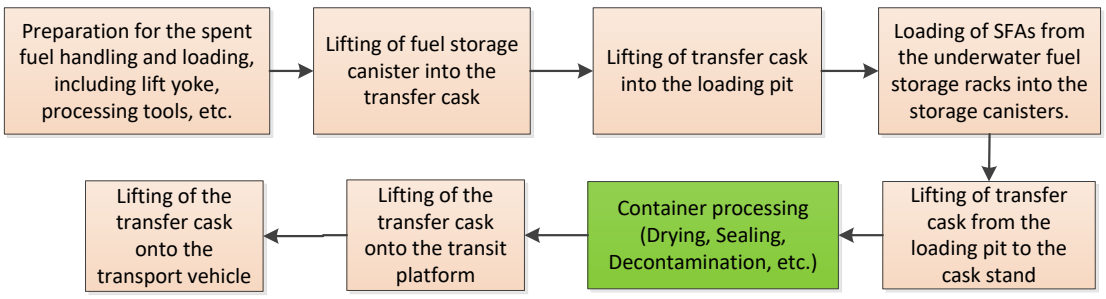

Figure 2 Flow Diagram of SFIS Operations in BFX

The flow diagram of SFIS operations within the BFX is presented in the figure 2, in which the orange part represents the lifting operations and the green part represents the canister/cask processing operations. The risks associated with lifting operations are included in RO-UK HPR1000-0014 while other risks (not relevant to lifting) are considered in RO-UK HPR1000-0050. A general introduction to SFIS operations is presented in *Spent Fuel Interim Storage Facility Design*, Reference [15], which is consistent with *UK HPR1000 GDA Scope for Spent Fuel Interim Storage (SFIS)*, Reference [16]. RO-UK HPR1000-0056 focuses on the assessment of cask drop risks and relevant radiological consequence analysis.

1) Introduce the handling process of spent fuel casks. In order to provide a clear input for the safety case for the

handling of spent fuel casks within the BFX, the description of handling process of spent fuel casks after design modification to the BFX will be updated in the *Fuel Handling Process and Operations*, Reference [1].

2) Re-evaluate PIEs. The PIE identification will focus on spent fuel delivery process within the BFX. The PIEs related to handling of spent fuel casks are identified through the process presented below, which is presented in *PIE List of UK HPR1000 of Internal Event (Except for Loss of Support System)*, Reference [2].
   - Identification of fuel route steps;
   - Identification of possible failures in each step of fuel route;
   - Qualitative consequences analysis. For each failure, qualitative consequence analysis will be performed;
   - Fuel route PIE. Failures, except for those excluded by qualitative analysis, will be considered as fuel route PIEs.

   The unmitigated consequence analysis for the PIEs identified is presented in *On-site Radiological Consequence Evaluation for Fuel Route PIE* , Reference [3].

   The identification process of fuel route PIEs will be reviewed based on the design modifications to the BFX included in DR Version 2.2. The Reference [2] will be updated if new PIEs are identified.

3) Identify risk and evaluate consequence. The process and operations of the handling of spent fuel casks within the BFX will be reviewed to identify relevant risks. The evaluation will focus on the fault studies, internal hazards (e.g. dropped load), radiological consequence and conventional health and safety.

   As an important part of this RO, the risks of cask drop during transfer within the BFX will be identified. By qualitatively comparing the possibility and consequence of different dropped load cases, a bounding case will be identified to assess the radioactive consequence of cask drop within the BFX, which will be addressed in a new report titled *Radiological Consequence Analysis of Dropping of Spent Fuel Cask*.

   In order to summarise the whole demonstration that relevant risks are reduced to ALARP, the ALARP demonstration reports in different technical areas will be updated according to the risk assessment result based on the latest design of the BFX.

   a) For the risks associated with potential radiological consequences, relevant assessment will be addressed in the new report titled *Radiological Consequence Analysis of Dropping of Spent Fuel Cask*.

   b) The risk of spent fuel cask drop needs to be analysed from the following three aspects:
      - The integrity and radioactivity confinement of spent fuel cask, which will be addressed in the *Radiological Consequence Analysis of Dropping of Spent Fuel Cask*.
      - The impact on the equipment important to safety in the impacted area of dropped loads. As shown in *Dropped Loads Safety Assessment Report for Fuel Building*, Reference [8], only one train of equipment are located in the impacted area of spent fuel cask, the safety function can be ensured after the dropped loads.
      - The impact on structures. There are impact limiters under the cleaning pit and loading pit. The structure can maintain integrity in case of spent fuel cask drop. The drop of spent fuel cask in hoisting pit can be bounded by the 18.3m drop which is presented in *Impact Analysis of Design Modification on Civil Engineering*, Reference [9].

   c) For the conventional health and safety, the fuel handling process and operations will be reviewed, and corresponding DRRs will be updated if necessary.

d) For the risks associated with lifting operations in BFX, the existing document *ALARP Assessment of the Spent Fuel Delivery Process* , Reference [17], will be updated if necessary.

e) For the risk concerned to canister/cask processing in BFX, the existing document *ALARP Demonstration of Spent Fuel Interim Storage,* Reference [18], will be updated according to the modification with the BFX.

4) Carry out optioneering and update related documents. If gaps or shortfalls have been identified in the previous steps, an optioneering should be carried out to select the best option which can reduce the overall risks to ALARP, and then implement the design improvement at a conceptual level during GDA. A comprehensive impact analysis should be carried out by all relevant disciplines and topic areas. Impacted documents will be updated appropriately before April 30th, 2021.

Deliverables (reports):

No.	Deliverable	Type	Schedule
1	Fuel Handling Process and Operations	Update	31/12/2020
2	PIE List of UK HPR1000 of Internal Event (Except for Loss of Support System)	Update if necessary	08/01/2021
	On-site Radiological Consequence Evaluation for Fuel Route PIE	Update if necessary	24/12/2020
3	Radiological Consequence Analysis of Dropping of Spent Fuel Cask	New	30/01/2021
	ALARP Assessment of the Spent Fuel Delivery Process	Update if necessary	30/01/2021
	ALARP Demonstration of Spent Fuel Interim Storage	Update if necessary	30/01/2021

Resources: CGN Mechanical Engineering (ME) team, fault studies team, internal hazard team, radiological protection, environmental, human factor team, layout team, NLR team, CH&S and the UK TSC.

Reference

[1] CGN, Fuel Handling Process and Operations, GHX00100008DPFJ45GN, Rev. C, June 2020.

[2] CGN, PIE List of UK HPR1000 of Internal Event (Except for Loss of Support System), GHX00100110DOZJ03GN, Revision E, August 2020.

[3] CGN, On-site Radiological Consequence Evaluation for Fuel Route PIE, GHX00530035DNFP02GN, November 2019.

[4] CGN, Dropping of Fuel Assembly, GHX00600131DRAF02GN, Rev. D, June 2020.

[5] CGN, Worker Dose Assessment for Representative Design Basis Accidents, GHX00530011DNFP02GN, Rev. C, September 2020.

[6] CGN, On-site (MCR) Radiological Consequences analysis for Representative DBC Accidents of UK HPR1000, GHX00100010DOHB00GN, Rev. A, July 2020.

[7] CGN, Off-site Radiological Consequences analysis for Representative DBC Accidents of UK HPR1000, GHX00100011DOHB00GN, Rev. A, July 2020.

[8] CGN, Dropped Loads Safety Assessment Report for Fuel Building, GHX84200048DOZJ03GN, Rev. A, October 2020.

[9] CGN, Impact Analysis of Design Modification on Civil Engineering, GHXNIX10059DWJG42GN, Revision A, December 2020.

[10] CGN, PMC Conventional Health and Safety Design Risk Register, GHX00100013DPFJ03GN, Rev. D, November 2020.

[11] CGN, ALARP Assessment of the BFX Cranes Arrangements, GHX00100011DPFJ45GN, Rev. A, November 2020.

[12] CGN, Classification of the Typical Cranes, GHX45600013DPZS45GN, Rev. C, November 2020.

[13] CGN, Technical Specification for Nuclear Lifting and Handling Equipment, GHX45600011DPZS45GN, Rev. C, August 2020.

[14] CGN, Technical Specification for Spent Fuel Pool Crane, GHX45600007DPFJ44DS, Rev. B, November 2020.

[15] CGN, Spent Fuel Interim Storage Facility Design, GHX00100081DNFF03GN, Revision E, September 2020.

[16] ONR/EA, UK HPR1000 GDA Scope for Spent Fuel Interim Storage (SFIS), REG-GNS-0031N, October 2018.

[17] CGN, ALARP Assessment of the Spent Fuel Delivery Process, GHX00100012DPFJ45GN, Rev. A, November 2020.

[18] CGN, ALARP Demonstration of Spent Fuel Interim Storage, GHX00100074KPGB03GN, Rev. C, April 2020.

Impact on the GDA Submissions

The impacted documents are listed in the sections of "Deliverables (reports)". In addition, the results of the risk analysis may lead to design modifications. These will be reflected in the UK HPR1000 safety case documentation.

Examples of affected UK HPR1000 safety case documentation may include:

- UK PCSR Sub-chapters
- Support Evidence Documents
- General arrangement drawings
- Dedicated safety assessment reports

See attached Gantt Chart in APPENDIX A.

Timetable and Milestone Programme Leading to the Deliverables

Attach a Gantt chart to present the timetable and milestone of the RO resolution in APPENDIX A.

Reference

PREVIOUS REVISIONS RECORD				
Rev.	**Author**	**Scope/Reason of Revision**	**Date**	**Page**

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APPENDIX A RO-UKHPR1000-0056 Gantt Chart

Task and Schedule		2020												2021				
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
RO Action 1																		
1	Fuel Handling Process and Operations											■	■					
2	PIE List of UK HPR1000 of Internal Event (Except for Loss of Support System)(if necessary)											■	■	■				
3	On-site Radiological Consequence Evaluation for Fuel Route PIE(if necessary)											■	■	■				
4	Dropping of Fuel Assembly											■	■	■				
5	Worker Dose Assessment for Representative Design Basis Accidents(if necessary)											■	■	■				
6	On-site (MCR) Radiological Consequences analysis for Representative DBC Accidents of UK HPR1000(if necessary)											■	■	■				
7	Off-site Radiological Consequences analysis for Representative DBC Accidents of UK HPR1000(if necessary)											■	■	■				
8	Dropped Loads Safety Assessment Report for Fuel Building(if necessary)											■	■	■				
9	Impact Analysis of Design Modification on Civil Engineering (if necessary)											■	■	■				
10	PMC Conventional Health and Safety Design Risk Register(if necessary)											■	■	■				
11	ALARP Assessment of the BFX Cranes Arrangements											■	■	■				
12	Classification of the Typical Cranes											■	■	■				
13	Technical Specification for Nuclear Lifting and Handling Equipment(if necessary)											■	■	■				
14	Technical Specification for Spent Fuel Pool Crane(if necessary)																	
15	Target ROA1 Closure															▲		
RO Action 2																		
1	Fuel Handling Process and Operations											■	■					
2	PIE List of UK HPR1000 of Internal Event (Except for Loss of Support System) (if necessary)											■	■	■				
3	On-site Radiological Consequence Evaluation for Fuel Route PIE(if necessary)											■	■	■				

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4	Radiological Consequence Analysis of Dropping of Spent Fuel Cask																		
5	ALARP Assessment of the Spent Fuel Delivery Process(if necessary)																		
6	ALARP Demonstration of Spent Fuel Interim Storage(if necessary)																		
	Target ROA2 Closure																		
Assessment																			
	Regulatory Assessment																		
	Target RO Closure Date																		