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REGULATORY OBSERVATION Resolution Plan	
RO Unique No.:	RO-UKHPR1000-0008
RO Title:	Justification of the Structural Integrity Classification of the Main Coolant Loop
Technical Area(s)	Structural Integrity
Revision:	Rev 1
Overall RO Closure Date (Planned):	30/06/2020
Linked RQ(s)	RQ-UKHPR1000-0007 (TRIM 2017/469062) RQ-UKHPR1000-0090 (TRIM 2018/183367) RQ-UKHPR1000-0102 (TRIM 2018/192675) RQ-UKHPR1000-0115 (TRIM 2018/232334)
Linked RO(s)	-
Related Technical Area(s)	1. Chemistry 9. Fault Studies 10. Fuel & Core 11. Human Factors 12. Internal Hazards 13. Management of Safety Quality Assurance 14. Mechanical Engineering 16. Radiological Protection 18. Security
Other Related Documentation	-

Scope of Work

Background

ONR's safety assessment guidance requires that the As Low As Reasonably Practicable (ALARP or So Far As Is Reasonably Practicable (SFAIRP)) shall be applied to the risk analysis of structures and components. An important aspect for the ALARP demonstration is the safety classification of the Structures, Systems and Components (SSC). ONR's structural integrity assessment guidance covers the following two types:

1) The approach that should be followed for highest reliability structures and components, where the safety case argues that gross failures can be discounted;

2) The approach for other components and structures, where robust consequence arguments are expected when gross failure is not discounted.

In the reference design for the UK version of the Hua-long Pressurised Reactor (UK HPR1000), namely, Fangchenggang Unit 3 (FCG3), Leak Before Break (LBB) arguments are applied to the Main Coolant Line (MCL). This effectively precludes the need to consider the consequences of postulated gross failure, thus physical protection is not necessary for the MCLs of the reference design. However, to meet ONR's expectations, for the UK HPR1000, LBB is a secondary argument providing defence-in-depth to the SI demonstration. The Requesting Party (RP) has developed an approach to SI classification founded on a systematic consideration of the direct and indirect consequences of postulated gross failures. The RP's

approach allows for the identification of those structures and components that require a highest reliability claim. In the RP's SI classification scheme, highest reliability structures and components are referred to as High Integrity Components (HICs).

During the latter stages of Step 2 of the GDA for the UK HPR1000, the RP identified the MCL as a 'definite' HIC (Ref.1) governed by the indirect consequences, which means that the direct consequences e.g. Large Break Loss Of Coolant Accident (LBLOCA) were held to be within the design basis. However in Chapter 12 of the Preliminary Safety Report (PSR), the design basis for a LBLOCA is limited to a gross failure of the pressuriser surge line (Ref.2). References related to the consequence analyses, which inform the structural integrity classification of the MCL were not provided.

A principal conclusion from ONR's Step 2 structural integrity assessment (Ref.3) was therefore that there were important gaps in the RP's case to adequately justify the structural integrity classification of the MCL. Furthermore, there was insufficient information to form a judgement on whether the structural integrity classification of the MCL is appropriate and commensurate with reducing risks to ALARP.

In order to address RO-UKHPR1000-0008 and to achieve ONR's expectations, this resolution plan is developed to outline the programme of work. The work to address each action of the RO is detailed below.

Abbreviations and Acronyms

ALARP	As Low As Reasonably Practicable
FCG 3	Fangchenggang Unit 3
GDA	Generic Design Assessment
HIC	High Integrity Component
LBB	Leak Before Break
LBLOCA	Large Break Loss Of Coolant Accident
LOCA	Loss of Coolant Accident
MCL	Main Coolant Line
ONR	Office for Nuclear Regulation
OPEX	Operational Experience
PCSR	Pre-Construction Safety Report
PSR	Preliminary Safety Report
RCS	Reactor Coolant System
RO	Regulatory Observation
ROA	Regulatory Observatory Actions
RP	Requesting Party
SFAIRP	So Far As Is Reasonably Practicable
SI	Structural Integrity
SSC	Structures, Systems and Components
UK HPR1000	The UK Version of the Hua-long Pressurized Reactor
UK	United Kingdom of Great Britain and Norther Ireland

Scope of work

In accordance with the regulatory observation actions of RO-UKHPR1000-0008, the scope of work in this resolution plan covers four aspects:

1) Process to Establish the SI Classification of the MCL.
2) MCL Consequence Analyses, Design Optioneering and Identification of Measures to Reduce Risk.
3) Justification that the SI Classification of the MCL is Commensurate with Reducing Risks SFAIRP.
4) Demonstration of the Adequacy of the MCL SI Safety Case.

On the basis of the documentation submitted prior to Step 3 and the planned step 3 and step 4 submissions, and taking cognisance of the regulatory expectations, the following documents will be updated or produced to address this RO and achieve ONR's regulatory expectations.

1) ***MCLs SI Classification Approach***
2) ***MCLs Failure Consequence Analysis Report***
3) ***High Level ALARP Assessment for Main Coolant Line Structural Integrity Classification***
4) ***Main Coolant Lines Component Safety Report***
5) ***MCLs SI Classification Conclusion***
6) ***Safety Case Methodology for HIC and SIC Components***
7) ***PCSR Chapter 17 (if necessary)***

This Resolution Plan describes the current plan to address RO-UKHPR1000-0008. However, as the work develops, it may be necessary to adjust or update this plan to align with the latest review schedule in agreement with the regulators.

Note this Resolution Plan is specific to justifying the structural integrity classification of the MCL. It is not expected that the structural integrity classification of other HIC candidate components is addressed to close this RO. However, the RP's approach developed for the MCL may be used or adapted to establish the classification of other HIC candidate components.

Deliverable Description

RO-UKHPR1000-0008.A1 – Process to Establish the Structural Integrity Classification of the MCL

The RO Action 1 states that:

In response to this ROA, the RP should:

Explain the approach they will develop and implement to establish the MCL structural integrity classification in GDA.

ONR considers that the response to this Action should include information on:

- *The strategy, key steps and inputs expected to inform the development of the approach.*
- *The technical disciplines that will be involved, along with the management oversight and governance*

arrangements that will address potential technical conflicts between disciplines, to inform a robust, consolidated position on design options.

- *The presentation of a documented evidence trail to underpin the decision making process.*
- *The timescales for providing the justification of the MCL structural integrity classification to ONR, taking cognisance of the availability of the key supporting information and relevant inter-dependencies.*

Resolution Plan

RP has developed an approach to SI classification founded on a systematic consideration of the consequences of the MCLs postulated gross failures as a double-ended break (2A-LOCA) which is the most severe LOCA. The "***MCLs SI Classification Approach***" will be produced in response to RO Action 1, which will be submitted before April 30th 2019.

This approach will describe the followings:

1) SI classification strategy and methodologies

The MCLs SI Classification is carried out systematically according to the methodologies indicated in the approach:

a) The MCLs failure mode is identified.
b) The direct failure consequence analyses are performed based on the current UK HPR1000 design, including the fault study, LOCA transient analysis, LOCA hydraulic and mechanical loads analysis. The potential design modifications will be considered to reduce the risk to ALARP.
c) The indirect failure consequence analyses are also performed based on the current UK HPR1000 design to identify the internal hazards that could affect the safety of the facilities due to the potential gross failure of the MCLs. The impacts of pipe whip, jet impingement, internal flooding, mass and energy release to the relevant compartments are assessed. The potential for design modifications will be considered to reduce the risk to ALARP.
d) Based on the MCLs failure consequence analyses, the related risks are identified, and possible design modifications will be considered as the options for the ALARP assessment.
e) The ALARP analysis of the MCLs SI classification will be carried out using the current UK HPR1000 design along with other options identified from the failure consequence analyses. This evaluation will take a balanced consideration of the benefits, detriments and application of gross disproportion.
f) The MCLs SI classification and ALARP is determined by the above actions. The updated information will be incorporated into the relevant documents and PCSR chapters.

The MCLs SI classification flowchart and the detailed design activities are indicated in a new submission "***MCLs SI Classification Approach***".

2) Organisation and Management

In the "***MCLs SI Classification Approach***", the MCL SI classification work has been well organised and controlled under the guidance of *"**UK HPR1000 GDA Project Technical Organisation Planning**"*.

The RP has established a MCLs SI classification design team. The relationships between the relevant areas

are explicitly explained in the "***MCLs SI Classification Approach***".

The design activity management including conflict resolution, ALARP decision making, input control, design review/verification, output control, schedule and quality control has been formulated in the "***MCLs SI Classification Approach***".

3) Schedule

In the "***MCLs SI Classification Approach***", the related activities are organised with the time schedule (see Appendix A), and the work will be monitored.

RO-UKHPR1000-000N.A2 – MCL Consequence Analyses, Design Optioneering and Identification of Measures to Reduce Risk

The RO Action 2 states that:

The RP should provide a demonstration of the adequacy of the consequence analyses (direct and indirect) that will inform the structural integrity classification of the MCL.

ONR considers that the response to this Action should include information on:

- *The scope of the consequence analyses (direct and indirect);*
- *initiating event frequencies;*
- *key assumptions; and*
- *Subsequent comparison with the relevant design basis criteria.*

ONR anticipates that existing or planned transient analysis and internal hazards considerations will provide useful information for the RP to address this action. However, the intent of this Action is for the RP to demonstrate that the scope of the analyses is sufficient to inform the classification of the MCL.

Resolution Plan

The "***MCLs Failure Consequence Analysis Report***" will be produced to respond the Action 2 which will be submitted before July 30th, 2019.

This report, covers the initiating event frequencies, key assumptions, methods, design criteria and subsequent results for direct and indirect consequence analyses activities; such as faulty study, internal flooding. The report will inform the basis and potential for implementing design improvements to mitigate the identified risks.

The main scope of this report is summarised in the following table:

	Key step	Description
Failure mode	MCLs failure mode	• To identify the MCLs failure mode taking into account the OPEX, design features, material properties, and operating conditions • To postulate and justify the break locations for the MCLs SI classification
Direct failure consequence analysis	Fault study	• To analyse the integrity of the reactor core and containment after MCLs 2A- LOCA
	Transient analysis	• To study the Reactor Coolant System (RCP)[RCS] transients (including time history of temperature, pressure, flowrate, etc.) which acts as the inputs for RCP[RCS] and component thermal and hydraulic design
	Hydraulic and mechanical load analysis of LOCA	• To analyse the hydraulic effect or load caused by 2A-LOCA • To perform the loop dynamic analysis under 2A- LOCA condition • To analyse whether the components (including fuel assembly) could withstand the hydraulic and mechanical loads caused by 2A- LOCA • To assess whether the relevant civil structures could withstand the hydraulic and mechanical loads caused by 2A- LOCA
Indirect failure consequence analysis	Pipe whip	• To establish the pipe whip model • To identify the influenced components and structures • To calculate the pipe whip load • To assess pipe whip impact on the identified components and structures
	Jet impingement	• To establish the jet impingement model • To identify the influenced components and structures • To calculate the jet impingement load • To assess jet impingement impact on the identified components and structures
	Internal flooding	• To assess the internal flooding caused by MCLs 2A-LOCA

	Mass and energy release (compartment)	• To calculate the temperature and increased pressure in each relevant compartment caused by the MCLs 2A-LOCA • To assess the mass and energy impact on the civil walls

For the above failure consequence analyses, the combination of direct and indirect consequences will be considered.

RO-UKHPR1000-000N.A3 – Justification that the Structural Integrity Classification of the MCL is Commensurate with Reducing Risks SFAIRP

The RO Action 3 states that:

The RP should provide a demonstration that the structural integrity classification of the MCL is commensurate with reducing risks ALARP with a balanced consideration of the benefits, detriments and application of gross disproportion i.e. ALARP optioneering.
ONR considers that the response to this Action should include information on:

- *The design optioneering to identify measures to limit the consequences (direct and indirect) of postulated gross failures to within the design basis, including world-wide OPEX e.g. larger accumulators, piping restraints etc.*
- *The identification of potential measures to reduce risk, including world-wide OPEX.*
- *The consideration, and if reasonably practicable, the implementation of measures to avoid a highest reliability claim for the MCL.*
- *The consideration, and if reasonably practicable, the implementation of measures to reduce the consequences (direct and indirect) of a failure of the MCL.*

A demonstration that the structural integrity classification of the MCL is aligned to the UK HPR1000 plant classification of SSC.

Resolution Plan

Informed by the outcome of the consequence analyses, risks will be identified. The approach will follow the ALARP methodology, and considerations will be given to reducing the consequences (direct and indirect) of the MCLs failure. The ALARP assessment will include potential design modifications and subject to balancing the benefits, detriments and application of gross disproportion under the guidance of the "***MCLs SI Classification Approach***". The approach will also consider whether it is reasonably practicable to either avoid a HIC claim or to reduce risks. The basis for dismissing options will also be recorded.

The ALARP processes will be documented in "***High Level ALARP Assessment for Main Coolant Line Structural Integrity Classification***" which will be submitted before July 30th, 2019 in response to Action 3.

The main contents of the ALARP assessment report are:

- Risk identification
- Design option description
- Feasibility study of design option
- Conclusion

RO-UKHPR1000-000N.A4 – Demonstration of the Adequacy of the MCL Structural Integrity Safety Case

The RO Action 4 states that:

The RP should produce a strategy for providing an adequate structural integrity safety case for the MCL, which is informed by the structural integrity classification.
ONR considers that the response to this Action should include information on:

- *The proposed structural integrity case and provisions to underpin a non-HIC structural integrity claim; or*
- *The proposed structural integrity case and provisions to underpin a HIC structural integrity claim.*
- *The provision for updating the fault schedule taking cognisance of the MCL structural integrity classification.*
- *The provision for updating the hazard schedule taking cognisance of the MCL classification.*

Resolution Plan

1) The "***MCLs SI Classification Conclusion***", which refers all the related evidence for the MCLs SI classification, will be provided to ONR as the MCLs SI classification finishes.

2) The "***Safety Case Methodology for HIC and SIC Components***" will be updated to clearly and systematically identify the need for structural integrity safety cases along with the relevant provisions for HIC or non-HIC components. It will guide RP to construct adequate and reasonable arguments and evidence to underpin the structural integrity Claim of the MCLs.

3) For the MCLs structural integrity demonstration, safety cases will be provided in the "***Main Coolant Lines Component Safety Report***". This will provide linkage to specific Arguments and Evidence.

4) The relevant provisions of updating the fault schedule and hazard schedule after completing MCLs SI classification will be presented in the *"**MCLs SI Classification Approach**"*. The aim will be to inform relevant disciplines to ensure consistency between structural integrity classification and fault/hazard schedule. Once the MCLs SI classification is finalised, all the related documents will be checked and listed in *"**MCLs SI Classification Conclusion**"*.

Impact on the GDA Submissions

The supporting submissions are involved in this resolution plan.

GDA Submission Document	Related ROAs	Planned schedule for submission
MCLs SI Classification Approach	ROA1	30th April 2019
MCLs Failure Consequence Analysis Report	ROA2	30th July 2019
High Level ALARP Assessment for Main Coolant Line Structural Integrity Classification	ROA3	30th July 2019
Main Coolant Lines Component Safety Report (Rev. B)	ROA4	30th August 2019
MCLs SI Classification Conclusion (Rev. A)	ROA4	30th August 2019
Main Coolant Lines Component Safety Report (Rev. C)	ROA4	30th November 2019
MCLs SI Classification Conclusion (Rev. B)	ROA4	30th November 2019
Safety Case Methodology for HIC and SIC Components (Rev. C)	ROA4	30th April 2019*
Safety Case Methodology for HIC and SIC Components (Rev. D)	ROA4	20th November 2019*
Related document updating if necessary such as PCSR Chapter 17	ROA4	31th December 2019

* Note: This planned schedule for submission is in compliance with ROA2 of RO-UKHPR1000-0006.

Timetable and Milestone Programme Leading to the Deliverables

See attached Gantt Chart in APPENDIX A.

Reference

[1] Generic Design Assessment for UK HPR1000, Equipment Structural Integrity List, GH X 30000 003 DOZJ 03 GN, Rev. D, 29 May 2018. TRIM 2018/184876.

[2] UKHPR1000 GDA Project. Preliminary Safety Report Chapter 12 Design Basis Conditions Analysis. HPR/GDA/PSR/0012 Revision 0, October 2017. TRIM 2017/40136.

[3] ONR-GDA-UKHPR1000-AP-18-018 Revision 0, GDA Step 2 Assessment of Structural Integrity of the UK HPR1000 Reactor, November 2018.

PREVIOUS REVISIONS RECORD

Rev.	Author	Scope/Reason of Revision	Date	Page
0	[redacted]	*The first revision.*	*2019.9*	*13*

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APPENDIX A RO-UKHPR1000-0008 Gantt Chart

	Nov-18	Dec-18	Jan-19	Feb-19	Mar-19	Apr-19	May-19	Jun-19	Jul-19	Aug-19	Sep-19	Oct-19	Nov-19	Dec-19	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20
RO Action 1																				
Development of MCLs SI classification approach																				
Preparation of deliverable - [MCLs SI Classification Approach]																				
Submission of deliverable - [MCLs SI Classification Approach]																				
RO Action 2																				
Direct consequence analysis of MCLs failure																				
Indirect consequence analysis of MCLs failure																				
Preparation of deliverable - [MCLs Failure Consequence Analysis Report]																				
Submission of deliverable - [MCLs Failure Consequence Analysis Report]																				
RO Action 3																				
Design modifications consideration and optioneering																				
Preparation of deliverable - [High Level ALARP Assessment for Main Coolant Line Structural Integrity Classification]																				
Submission of deliverable - [High Level ALARP Assessment for Main Coolant Line Structural Integrity Classification]																				
RO Action 4																				
Preparation of deliverables - [Main Coolant Lines Component Safety Report] & [MCLs SI Classification Conclusion]																				
Submission of deliverables - [Main Coolant Lines Component Safety Report] and [MCLs SI Classification Conclusion]																				
Preparation of deliverables-[Safety Case Methodology for HIC and SIC Components] (Rev. C & D)																				
Submission of deliverables-[Safety Case Methodology for HIC and SIC Components] (Rev. C & D)																				
Related document updating if necessary such as PCSR Chapter 17																				
Submission of related document																				
Assessment																				
Regulator Assessment																				
Target RO Closure Date																				

Main Coolant Lines Component Safety Report Rev. B & MCLs SI Classification Conclusion Rev. A

Rev. C

Rev. D

Main Coolant Lines Component Safety Report Rev. C

MCLs SI Classification Conclusion Rev. B