REGULATORY OBSERVATION

REGULATOR TO COMPLETE

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Observation title:	Justification of the Structural Integrity Classification of the Main Coolant Loop
Lead technical topic: 20. Structural Integrity	**Related technical topic(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

Regulatory Observation

Background

ONR's safety assessment guidance requires that the risks arising from the postulated gross failure of structures and components are reduced so far as is reasonably practicable (SFAIRP). Note SFAIRP is the legal term derived from the 1974 Health and Safety at Work Act etc.; for the purposes of this Regulatory Observation (RO) the term as low as reasonably practicable (ALARP) is also used. A key aspect to demonstrating risks are reduced ALARP is the safety classification of structures, systems and components (SSC). For structural integrity, ONR's assessment guidance covers two types of situation; firstly, the approach that should be followed for highest reliability structures and components, where the safety case argues that gross failures can be discounted; secondly 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 HPR1000, namely, Fangchenggang Unit 3 (FCG3), leak before break (LBB) arguments are applied to the Main Coolant Loop (MCL). This effectively precludes the need to consider the consequences of postulated gross failure. However, to meet ONR's expectations, for the UK HPR1000, the Requesting Party (RP), has developed an approach to structural integrity 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 structural integrity classification scheme, highest reliability structures and components are referred to as Highest 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 [1]. They claimed that the structural integrity classification of the MCL was governed by the indirect consequences i.e. pipewhip. Notably, the direct consequences e.g. large break loss of coolant accident (LBLOCA) were now held to be within the design basis, whereas 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 [2]. This notwithstanding, at GDA Step 2, references to the consequence analyses, which inform the structural integrity classification of the MCL were not provided in the Structural Integrity Equipment list[1].

As previously explained, the UK regulatory regime places a particular requirement on the duty holder to demonstrate that they have reduced risks. In this context, therefore, the starting position for the structural integrity classification of the MCL is, if reasonably practicable, to avoid highest reliability claims. This follows because a highest reliability claim is an onerous route to a safety case which carries a high burden of proof in design and through-life, with the expectation of measures above normal practice i.e. the structural integrity provisions of established nuclear pressure vessel design, construction and inspection codes.

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

This RO is therefore raised to:

- Address the gaps identified during ONR's Step 2 Structural Integrity assessment [3] and to clearly articulate ONR's regulatory expectations;
- Gain confidence that the RP will develop satisfactory processes to establish the structural integrity classification of the MCL in a timely manner for GDA.
- Ensure that the structural integrity classification of the MCL is soundly based, aligned with the plant classification of SSCs and commensurate with reducing risks to ALARP;
- Clarify the structure and content of the MCL structural integrity case given either a non-HIC, or HIC, structural integrity classification.

Relevant Legislation, Standards and Guidance

A key safety principle within the ONR Safety Assessment Principles (SAPs), and internationally, relates to achieving defence-in-depth for nuclear facilities. The expectations for defence-in-depth, which relate to International Atomic Energy Agency (IAEA) guidance, along with those for metallic structures and components are contained within the ONR SAPs [4]. The following SAPs, expanded in TAG NS-TAST-GD-016, *Integrity of Metal Components and Structures* [5], are of particular relevance to this RO:

Engineering and Integrity of Metal Components and Structures Principles

EKP.3 Defence-in-depth

Nuclear facilities should be designed and operated so that defence in depth against potentially significant faults or failures is achieved by the provision of multiple independent barriers to fault progression.

ECS.2 Safety Classification of Structures, Systems and Components

Structures, systems and components that have to deliver safety functions should be identified and classified on the basis of those functions and their significance to safety.

ECS.3 Codes and Standards

Structures, systems and components that are important to safety should be designed, manufactured, constructed, installed, commissioned, quality assured, maintained, tested and inspected to the appropriate codes and standards.

Highest reliability components and structures, paragraph 286

Discounting gross failure of a component or structure is an onerous approach to constructing an adequate safety case. Cases following this approach should provide an in-depth explanation of the measures over and above normal practice that support and justify the claim that gross failures can be discounted.

EMC. 1 Safety case and assessment

The safety case should be especially robust and the corresponding assessment suitably demanding, in order that a properly informed engineering judgement can be made that:

(a) the metal component or structure is as defect-free as possible; and

(b) the metal component or structure is tolerant of defects.

EMC. 2 Use of scientific and technical issues

The safety case and its assessment should include a comprehensive examination of relevant scientific and technical issues, taking account of precedent when available.

EMC.2 paragraph 293
Wherever possible, safety cases should not rely on claims of extremely high structural integrity.

EMC.3 Evidence
Evidence should be provided to demonstrate that the necessary level of integrity has been achieved for the most demanding situations identified in the safety case.

EMC.3 paragraph 295
To meet Principles EMC.1 and EMC.2, the safety case should include appropriate evidence of the following: (a) to (p).

Fault Analysis Principles
FA.3 Fault Sequences
Fault sequences should be developed from the initiating faults and their potential consequences analysed.

FA.5 Initiating Faults
The safety case should list all initiating faults that are included within the design basis analysis of the facility.

FA.5 paragraph 628
Initiating faults identified in Principle FA.2 should be considered for inclusion in this list, but the following need not be included:
(a)…
(b) failures of structures, systems or components for which appropriate specific arguments for preventing the initiating fault have been made (see, for example, Principle EMC.3).

Internal Hazard Principles
EHA.1 Identification and characterisation
An effective process should be applied to identify and characterise all external and internal hazards that could affect the safety of the facility.

EHA.3 Design basis events
For each internal or external hazard which cannot be excluded on the basis of either low frequency or insignificant consequence (see Principle EHA.19), a design basis event should be derived.

EHA.5 Design basis event operating states
Analysis of design basis events should assume the event occurs simultaneously with the facility's most adverse permitted operating state (see paragraph 631 c) and d)).

EHA.6 Analysis
The effects of internal and external hazards that could affect the safety of the facility should be analysed. The analysis should take into account hazard combinations, simultaneous effects, common cause failures, defence in depth and consequential effects.

EHA.7 Cliff-edge effects
A small change in design basis fault or event assumptions should not lead to a disproportionate increase in radiological consequences.

EHA.18 Beyond design basis events
Fault sequences initiated by internal and external hazards beyond the design basis should be analysed applying an appropriate combination of engineering, deterministic and probabilistic assessments.

Regulatory Expectations

In summary, ONR's expectations for the UK HRP1000 MCL is that a suitable and sufficient justification is provided in the generic safety case regarding:

i) The development of adequate processes to establish the structural integrity classification of the MCL to inform the design of the UK HPR1000 in a timely manner to reduce the project and technical risks.
ii) The MCL consequence analyses (direct and indirect), along with design optioneering, taking cognisance of good practice, to identify measures which may reduce risk.
iii) The consideration, and if reasonably practicable, the implementation of measures to avoid high levels of structural integrity demonstration or to reduce risk (i.e. the provision of (further) defence-in-depth).

iv) The route and content of the structural integrity case for the MCL is demonstrably proportionate to the structural integrity classification, taking cognisance of the outcome of the design optioneering, and if appropriate, the implementation of reasonably practicable measures to reduce risks to ALARP.

Note this RO 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.

The Regulatory Observatory Actions (ROAs) given below are structured in a way to enable provision of information by the RP in a logical manner, to inform ONR's assessment and the progression of the GDA.

References

[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.
[4] Safety Assessment Principles for Nuclear Facilities, 2014 Edition, Revision 0, ONR, November 2014
[5] ONR's Technical Assessment Guide (TAG): NS-TAST-GD-016 Revision 5, March 2017. Integrity of Metal Components and Structures. http://www.onr.org.uk/operational/tech_asst_guides/ns-tast-gd-016.pdf

Regulatory Observation Actions

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

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 developmnet of the approach.
  - The technical disciplines that will be involved, along with the management oversight and governance arrangements that will address potentail technical conflicts between disciplnes, 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 cognisnace of the availability of the key supporting information and relevant inter-dependicies.

Resolution required by: To be determined by the RP's Resolution Plan.

RO-UKHPR1000-0008.A2 – MCL Consequence Analyses, Design Optioneering and Identification of Measures to Reduce Risk

In response to this ROA, and based on the response to ROA1, 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 exisiting 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 required by: To be determined by the RP's Resolution Plan.

RO-UKHPR1000-0008.A3 – Justification that the Structural Integrity Classification of the MCL is Commensurate with Reducing Risks SFAIRP

In response to this ROA, and based on the responses to ROAs 1-2, 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 implementtaion 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 alliged to the UK HPR1000 plant classification of SSC.

Resolution required by: To be determined by the RP's Resolution Plan.

RO-UKHPR1000-0008.A4 – Demonstration of the Adequacy of the MCL Structural Integrity Safety Case

In response to this ROA, and based on the responses to ROAs 1-3, the RP should:

- Produce a strategy for providing an adeqaute 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 cognisnace of the MCL classification.

Resolution required by: To be determined by the RP's Resolution Plan.

REQUESTING PARTY TO COMPLETE	
Actual Acknowledgement date:	
RP stated Resolution Plan agreement date:	