REGULATORY OBSERVATION

REGULATOR TO COMPLETE

RO unique no.:	RO-ABWR-0082
Date sent:	07 August 2017
Acknowledgement required by:	21 August 2017
Agreement of Resolution Plan Required by:	*To be determined by the Hitachi-GE Resolution Plan*
Resolution of Regulatory Observation required by:	*To be determined by the Hitachi-GE Resolution Plan*
TRIM Ref.:	2017/192261
Related RQ / RO No. and TRIM Ref. (if any)**:**	RQ-ABWR-0993 (TRIM Ref. 2016/279879); RQ-ABWR-1231 (TRIM Ref. 2017/482272); RQ-ABWR-1302 (TRIM Ref. 2017/47503); RQ-ABWR-1310 (TRIM Ref. 2017/64808); RQ-ABWR-1380 (TRIM Ref. 2017/111610); RQ-ABWR-1440 (TRIM Ref. 2017/176669); RQ-ABWR-1445 (TRIM Ref. 2017/182028).
Observation title:	Substantiation of the UK ABWR Class 1 Barriers against Internal Hazard Loads
Technical area(s) 1. Internal Hazards	**Related technical area(s)** 2. Civil Engineering

Regulatory Observation

Summary

As part of Step 4 of the UK ABWR GDA, Hitachi-GE has submitted Topic Reports [1]- [5] acknowledging that Class 1 Nuclear Safety Barriers are predicted to fail against a significant number of internal hazard events, including dropped loads and pipe whip outside containment. In addition, substantiation of Class 1 Barriers has not been provided against combined hazard loads and global effects. Substantiation of Reinforced Concrete (RC) structures is also essential to the proposed Turbine Disintegration case. Hitachi-GE has argued that, in the majority of the cases, detailed design information is required to substantiate the barriers, thus preventing resolution before the end of the GDA process. However, this argument is not robust, as it appears that the outstanding analysis is not dependent on design information which is pertinent to site specific information or licensee choices.

The short duration of elevated risk associated with failure of systems operating in High Energy modes for short periods of time has been used to justify the limited assessment so far performed on those systems. The impact on Class 1 barriers has not been assessed. System supports, the hazard compartments and surrounding Nuclear Safety barriers may not have been designed to withstand the Internal Hazard loads associated with failure in High Energy modes. For these cases, there is limited evidence that the risks have been reduced to As Low As Reasonably Practicable (ALARP).

Hitachi-GE has generally argued that, for Internal Hazards such as dropped loads and pipe whip, the predicted failure of the barriers results from the application of conservative assumptions and methodologies. Hitachi-GE has indicated that, once further information is available and the analysis methods are refined during detailed design, the barriers would be fully substantiated. For systems excluded from assessment on the basis of their operating regime (time-at risk), Hitachi-GE has considered that the low frequency of operation results in the scenarios being ‘Beyond Design Basis’ (BDB) and provided qualitative assessments.

The aim of this RO is to:

- Obtain clarity on the full set of cases where Class 1 barriers are predicted to fail against all Internal Hazard loads;

- Obtain assurances, based on robust evidence, that all Class 1 Nuclear Safety Barriers of the UK ABWR reference design can withstand all foreseeable Internal Hazard Loads, including dropped loads, pipe whip and combined hazards;
- Obtain consequence assessment of High Energy systems so far excluded on the basis of their operational regime and demonstration that all reasonably practicable measures will be implemented;
- Obtain confidence that, in all cases where the assessment of GDA reference design has resulted in the predicted failure of Nuclear Safety barriers, all reasonably practicable measures are available and will be implemented to demonstrate the sustained integrity of the barriers;
- Ensure that detailed design considerations during site-licensing do not result in significant changes to layout or the design of generic Class 1 barriers.

Background

Throughout Step 4 of GDA, ONR has assessed and raised a significant number of Regulatory Queries for Hitachi-GE to address the predicted failure of generic Class 1 barriers against Internal Hazard loads, including dropped loads, pipe whip and internal missiles: RQ-ABWR-0993 (TRIM Ref. 2016/279879); RQ-ABWR-1231 (TRIM Ref. 2017/482272); RQ-ABWR-1302 (TRIM Ref. 2017/47503); RQ-ABWR-1380 (TRIM Ref. 2017/111610) and RQ-ABWR-1445 (TRIM Ref. 2017/182028).

In the dropped loads assessment, Hitachi-GE has generally applied the R3 procedure in an attempt to substantiate the Class 1 slabs and this has resulted in the prediction that failure by perforation and/or scabbing is credible on the Reactor Building Operating Deck and Control Building. Hitachi-GE has proposed to perform Finite Element Modelling (FEM) to demonstrate the integrity of the barriers, post GDA.

The Pipe Whip and Jet Impact Topic Report predicts failure of Class 1 barriers against a single pipe impact in ~40 locations, given the reference GDA pipework layout. Consequential failures have been excluded from detailed assessment based on a perceived low probability of occurrence given US OPEX.

The assessment of Class 1 barriers against global effects e.g. compartment pressurisation, steam release, loss of unclassified supporting structures etc. has also not been provided.

Hitachi-GE has also excluded systems from assessment based on their operating regime. ONR regulatory expectations on the level of assessment required, and the requisite ALARP case was communicated in RQ-ABWR-1310. ONR's Safety Assessment Principle (SAP) NT.2 states that "*there should be control of radiological hazards at all times*". It is also ONR's expectation that "*the short duration of the increased risk should not be used as the sole argument for justifying risks are ALARP*" and that "*Any reasonably practicable step that can be taken to eliminate, reduce or mitigate increased risks should be taken even though the time of higher risk may be short*"

Responses to the above Regulatory Queries and Topic Reports, and technical discussions in meetings with Hitachi-GE have evidenced that satisfactory resolution of the above issues may not be achieved within the GDA Step 4 timeframe, unless a robust scope is developed and sufficient resource is allocated.

It should be stated here that the Class 1 barriers is a key claim within the internal hazards area and therefore lack of substantiation of these barriers renders the internal hazard safety case unsubstantiated.

Based on the information provided it appears that the design criteria to meet Internal Hazards requirements have not been captured in the civil design.

Regulatory expectation

It is ONR's expectation that, as part of the resolution of this RO, Hitachi-GE will provide the following:

- A consolidated list of internal hazard loads where the Class 1 Nuclear Safety barriers have not been fully substantiated against all foreseeable internal hazard loads, including dropped loads, pipe whip, missiles (conventional and Turbine-related), steam, combined loads and global effects/ responses.

- The proposed assessment methodologies, assumptions and base information (with reference to the generic design) that will be used in the assessments so any future changes through site-licensing and detailed design can be assessed against the substantiated generic design reference.
- Substantiation of the Generic Design against Internal Hazards loads including dropped loads, pipe whip, missiles, steam, combined loads and global effects in line with Hitachi-GE's primary claim of the Internal Hazards Safety Case.
    - Given the timescales available to complete the assessment, a pragmatic approach should be adopted. Hitachi-GE is required to make a proposal on the remaining substantiation of the barriers. This will involve detail consequences analysis consideration for the most challenging representative cases for each internal hazard, with the remaining cases considered qualitatively. Discussions on the remaining risk gap should be presented.
    - Demonstration that the assessment of all remaining cases will result in either substantiation of the barriers or that the requisite implementation of all reasonably practicable measures will lead to barrier substantiation. This includes providing evidence that the measures will not be foreclosed by the generic design (e.g. seismic qualification) and future assessment and detailed design will not result in the need for significant changes to layout.
- A clear, written design reference point documenting the status of all Class 1 barriers, the relevant Internal Hazard loads applicable to each barrier in turn and all the applicable measures to substantiate the barriers and reduce risks to ALARP.
- The reference document should also provide visibility of the risk gap carried forward to site licensing, with appropriate justification when further detailed design information is deemed to needed. This effectively means documenting, for each barrier in turn, the representative case studied/ applied to infer the response of the barrier (if the specific barrier response has not been explicitly assessed) and the committed changes /modifications to ensure that the barriers are substantiated. Detailed design considerations should be aligned with ONR's Guidance to Requesting Parties [6].
- Demonstration that the risks have been reduced to ALARP. This includes providing the consequences of failure of High Energy Systems excluded from assessment on the basis of their operating regime, to a level consistent with Hitachi-GE's methods for the relevant Internal Hazards. It also ONR's expectation that Hitachi-GE will provide an ALARP demonstration which will be commensurate with the consequences predicted and not purely based on the low frequency of operation of those systems.

References

[1] Concrete Structure Assessment against Heavy Drop for Reactor Building Operating Deck Rev 0 (LE-GD-0248), TRIM Ref. 2017/126532.

[2] Civil Structure Evaluation Report for Barrier Substantiation Rev. 0 (LE-GD-0322), TRIM Ref. 2016/483175.

[3] Topic Report on Dropped and Collapsed loads Rev 3 (LE-GD-0082), TRIM Ref. 2017/89772.

[4] Topic Report on Pipe Whip and Jet Impact Rev 4 (ZD-GD-0008), TRIM Ref. 2017/147432.

[5] Internal Hazards Barrier Substantiation Report Rev 3 (BKE-GD-0019), TRIM Ref. 2017/135784.

[6] New nuclear reactors: Generic Design Assessment: Guidance to Requesting Parties (ONR-GDA-GD-001 Revision 3; September 2016).

Regulatory Observation Actions

RO-ABWR-0082.A1

- Hitachi-GE to develop a consolidated list of cases where Class 1 Nuclear Safety barriers have not been fully substantiated against all foreseeable Internal Hazard loads including combined consequential events.

  This should include:
    - Identification of the status of all UK ABWR Class 1 barriers against IH loads. This should clearly identify those predicted to fail and those substantiated against specific hazards.
    - Identification of the failure mechanism e.g. scabbing, perforation, cone-cracking etc. as

applicable.

RO-ABWR-0082.A2

- Hitachi-GE to provide the proposed assessment methodologies, assumptions and base information needed for substantiation of the Class 1 barriers where different from the Step 4 methods e.g. R3 procedure.

  This should include:

  - Any revised pipe whip, dropped loads etc. methodologies.
  - The proposed method to assess combined loads on barriers, global responses including compartment pressurisation and failure of unclassified supporting elements.
  - Combined consequential events should be appropriately identified and quantitatively characterised (e.g. pipe and steam release, or pipe whip and jet impact or flood, or failure of multiple pipes in the same room).
  - A fully auditable trail of any assumptions, numeric models, equations and parameter values used in the calculations.

RO-ABWR-0082.A3

- Substantiation of a robust set of representative Class 1 barriers (which will cover the most challenging consequences and all the relevant internal hazards, combined loads and global effects) within the GDA step 4 timeframe.

  ONR expects that Hitachi-GE will:

  - Provide the assessment results according to the revised methodologies;
  - Perform sensitivity analyses to address uncertainty in the models, parameters and key assumptions;
  - Document the specific options / measures required to prevent the failure of each Class 1 barrier;
  - Demonstrate that the measures will not be foreclosed by the generic design (e.g. seismic qualification), and will remain available so that that future design considerations and assessment do not result in the need for significant changes to layout.
  - Hitachi-GE to document any required changes from the reference design so that they are carried forward into detailed design and site-specific licensing.

RO-ABWR-0082.A4

- Hitachi-GE to provide justification that, where the specific barrier is not in the representative set, substantiation can be achieved without significant changes to layout.

RO-ABWR-0082.A5

- Provide a safety case for the failure of those high pressure safety injection systems outside of containment that are tested periodically while the reactor is at power.

  This should include:

  - Identification of all relevant systems and their location.
  - Characterisation of the unmitigated consequences of the failure of the identified systems, including consequential damage to safety systems.
  - Identification of the SSCs claimed to protect against the consequences of the failure and the safety function they provide, for example check valves, safety injection, barriers, drains etc.
  - References to the evidence that supports the claims being made (e.g. fault studies analysis,

barrier substantiation calculations) and/or clearly identify what will need to be demonstrated during a later phase of UK ABWR development to support the safety case claims.

- Identification of any constraints on testing high pressure safety injection systems to be captured in Technical Specifications.

Resolution required by – to be determined by Hitachi-GE Resolution Plan

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