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BWRX-300 UK Generic Design Assessment (GDA) Response to Regulatory Observation (RO)

REGULATORY OBSERVATION Resolution Plan	
RO Unique No.	BWRX300-004
RO Title	Safety case for un-isolable and non-isolated pipe-breaks larger than 19 mm diameter
Technical Area(s)	Fault Studies
Revision	0
Overall RO Closure Date (Planned)	PCSR
Linked RQ(s)	RQ-01763 RQ-01770 RQ-01870
Linked RO(s)	N/A
Related Technical Area(s)	Internal Hazards PSA Structural Integrity
Other Related Documentation	GE-Hitachi, NEDO-34194 BWRX-300 UK GDA Chapter 22 Structural Integrity of Metallic System Structures and Components, Rev B, July 2025
Scope of Work	
<u>Background</u> The safety of the BWRX-300 is highly reliant on the twin redundant Reactor Isolation Valves (RIVs), and their connections to the Reactor Pressure Vessel (RPV), which are included in every large pipe exceeding 19 mm and passing through containment. No deterministic analysis was presented in the Preliminary Safety Report (PSR) covering un-isolable or non-isolated large breaks, which are Design Extension Conditions (DECs). This was acknowledged in Chapter 15.2 of the PSR where an explicit commitment was made to provide this deterministic analysis in the Pre-Construction Safety Report (PCSR), and which is a subset of the work involved in Forward Action Plan (FAP) item PSR15.5-30. The preliminary results of the deterministic analysis of the un-isolated large steamline breaks, Isolation Condenser (IC) steam line and return line breaks were shared with ONR. The results indicated that there is limited cladding heat up and no core damage. As stated in the RO, the submissions received to date have not provided ONR with sufficient clarity on the implications of the further deterministic analysis and the overall safety case for fault sequences involving un-isolable or non-isolated large break DECs. Specifically, ONR	

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described two regulatory expectations that need to be addressed, including (1) performing consequence analyses of gross failures of pressure retaining components (i.e., un-isolable large breaks between the RPV and RIVs) where the gross failure has not been discounted based on structural integrity arguments and (2) performing deterministic analysis to demonstrate the effectiveness of diverse safety measures for non-isolated large breaks in ICS piping, so far as reasonably practicable.

ONR consequently outlined an action in the RO requiring the development of a safety case covering un-isolable and non-isolated Loss of Coolant Accidents (LOCAs). This resolution plan outlines how GEH intends to respond to the action. The information provided as part of completion of the resolution plan will be assessed by ONR to close out the RO.

Scope of Work

To address this RO, the RP will provide the following:

- A topic report presenting a safety case for un-isolable / non-isolated large break DEC's.

Deliverable Description

RO-BWRX300-004.A1 – Safety Case for large unisolable/non-isolated LOCAs

ACTION

The RP should develop and submit a safety case for unisolable/non-isolated LOCAs in response to this Regulatory Observation Action.

In doing so, the RP should cover the following within that safety case:

- Additional deterministic analysis covering the consequences of the following sequences
 1. pipebreaks arising at the connection between the RPV nozzles and the RIVs.
 2. pipebreaks arising in isolable locations in the Isolation Condenser System (ICS) with subsequent common cause failure of the Primary Protection System (PPS) resulting in RIVs failing to close.
- Structural integrity justification and granulated classification of the pressure retaining structures, systems and components (SSCs) between the RPV nozzles and the RIVs as informed by the deterministic consequence analysis in accordance with the RP's process for High Integrity (as described in Chapter 22 of the PSR [Reference 1]).
- Identification of any additional safety measures (as required) to mitigate those consequences in accordance with suitable criteria.
- Identification of performance requirements, category of function ('Defence Line') and safety classification relating to any additional safety measures (as required).

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- As appropriate, demonstration of linkage between the above events, safety measures, their safety functions and performance requirements.

Regulatory Expectations

1. ONR's expectation is that consequence analyses of gross failures of pressure retaining components are performed where the gross failure has not been discounted based on structural integrity arguments. In the context of BWRX-300, the RP has not submitted sufficient evidence that gross failure of the RIVs or connection points to the RPV can be discounted.
2. ONR also expects that design basis techniques are applied down to sequence frequencies of 1×10^{-7} pa. This expectation is typically met by provision of a second line of protection as a backup to the principal means. ONR therefore expects diverse safety measures for pipebreaks on the ICS, where common cause failure (CCF) of the PPS prevents closure of the RIVs, so far as reasonably practicable. ONR also expect that deterministic analysis is performed to demonstrate the effectiveness of such safety measures, with fuel failures reduced to ALARP.

RESOLUTION PLAN

A topic report written for standard BWRX-300 plant will be produced presenting the deterministic safety case for un-isolable/non-isolated large breaks.

The safety case will be predicated on the current design position, which is that Extended Deterministic Safety Analysis (EX-DSA) for un-isolable/non-isolated large break DEC's are being performed to demonstrate that the BWRX-300 design can mitigate such fault sequences. The design position has continued to develop since the GDA design reference as the design work has progressed and will consequently align with the standard plant design. The topic report will analyze fault sequences involving:

- Large breaks in un-isolable locations between the RPV nozzles and the RIVs.
- Large breaks in isolable locations with failures in delivery of the isolation function.

and will cover the following elements:

- Calculation and justification of the Initiating Event Frequencies (IEFs) for the two fault sequences.
- Calculation and justification of the reliability of the SSCs involved.

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- Specification of the fault sequences that will be analyzed. This will include specification of: all safety measures [including supporting systems]; failures consequential on the initiating event; CCFs; and the initial operating state, in accordance with the BWRX-300 Safety Strategy [Reference 2] and contingent on the IEFs.
- Justification for any assumptions made in the EX-DSA.
- Demonstration that any adverse conditions arising from the initiating event will not undermine the claimed performance of the safety measures.
- Justification of any grouping of fault sequences protected by the same safety measures.
- The analyses will be conducted in accordance with the BWRX-300 Safety Strategy and are expected to use the EX-DSA approach, based on the expected IEFs of un-isolable and non-isolated large pipe breaks.
- Comparison of the results of the analyses with the appropriate BWRX-300 acceptance criteria, in accordance with the BWRX-300 Safety Strategy.
- Investigation of the existence of any cliff edges in accordance with the BWRX-300 Safety Strategy.
- Specification of the safety measures claimed in each fault sequence, their classification, the safety functions they deliver and their categorization and Defence Line (DL) location, along with any performance requirements, suitable for incorporation into the GEH fault evaluation fault list and UK fault schedule.
- Identification of limits and conditions as appropriate.

As the detailed design is developed, different approaches for addressing ONR's concerns may be considered, if necessary, and will be described in the topic report to support the PCSR. This may include the following:

- Reducing the IEF of un-isolable leaks.
- Decreasing the likelihood of consequential failures.
- Increasing the reliability of delivering the required safety functions.
- Providing a holistic consideration of the design effectiveness.

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The contents of the final topic report will ultimately be subsumed into the UK PCSR. Additionally, further risk reduction will be pursued in accordance with the ALARP process for UK site specific needs, as described in PSR Chapter 27 – ALARP Evaluation [Reference 3]. These, along with any additional UK-specific considerations, will be reported in UK PCSR.

Impact on GDA submissions

None

Timetable and Milestone Programme Leading to the Deliverables

Action A1 will be produced in timely advance of the UK PCSR.

The contents of the final topic report will be incorporated into the UK PCSR.

References

1. GE-Hitachi, NEDO-34194, BWRX-300 UK GDA Chapter 22 Structural Integrity of Metallic Systems, Structures and Components, Rev. B, July 2025.
2. GE-Hitachi, NEDO-33934, BWRX-300 Safety Strategy, Rev. 1, June 2024.
3. GE-Hitachi, NEDO-34199, BWRX-300 UK Preliminary Safety Report (PSR), Chapter 27 – ALARP Evaluation, Rev. B, July 2025.