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| **GDA Regulatory Observation** |
| **REGULATOR TO COMPLETE** |
| **RO unique no.:** | RO-BWRX300-004 |
| **Revision:** | 0 |
| **Date sent:** | 17/07/25 |
| **Acknowledgement required by:** | 08/08/25  |
| **Resolution Plan Agreement Required by:** | 05/09/25  |
| **Record Reference:** | ONRW-2126615823-7940 |
| **Related RQ / RO No. and CM9 Ref:** (if any)**:** | RQ-01763RQ-01770RQ-01870 |
| **Observation title:** | Safety case for un-isolable and non-isolated pipe-breaks larger than 19mm diameter |
| **Lead technical topic:**Fault Studies | **Related technical topic(s):**Internal HazardsProbabilistic Safety AnalysisStructural Integrity  |
| **REGULATORY OBSERVATION:** |
| **Background**Loss of coolant accidents (LOCAs) in light water reactors have the potential to challenge the fundamental safety functions of a reactor. Most notably, decay heat removal following reactor shutdown can be challenged as coolant is lost from the Reactor Pressure Vessel (RPV). Whilst traditional gigawatt-scale reactors have included injection systems to counteract the loss of coolant and enable continued heat removal, the BWRX-300 reactor employs an isolation system allowing the same heat removal systems to be credited for both non-LOCA and LOCA accidents. For this reason, the safety of the BWRX-300 is highly reliant on twin redundant Reactor Isolation Valves (RIVs) and their connections to the RPV. These RIVs are included in every large pipe exceeding 19mm diameter which passes through containment. They are located very close to the RPV to minimise un-isolable pipework. Following a large pipe break, they need to close rapidly to isolate the break from the RPV; this preserves the coolant inventory and enables passive core cooling via the Isolation Condenser System (ICS). Chapter 15.5 of the Preliminary Safety Report [ref. 1] provides a deterministic fault analysis which covers large isolable pipe breaks, the closure of the RIVs and successful core cooling via the ICS.Any un-isolable or non-isolated break has the potential to challenge core cooling via the ICS. During GDA, the RP has acknowledged and committed to performing further deterministic analysis of potential sequences [refs. 3 and 4]:1. Large breaks arising in un-isolable locations (e.g. between RPV nozzles and RIVs)
2. Large breaks arising in isolable locations with subsequent common cause failures (CCF) resulting in RIVs failing to close.

The RP has further indicated this deterministic analysis will be used to inform a more granular approach to structural integrity classifications of pressure retaining components and to identify further deterministic claims on SSCs [ref. 5].However, based on submissions to date, the implication of this further deterministic analysis and the overall safety case for these sequences remain unclear. ONR considers that the RP has not submitted sufficient evidence within the PSR [ref. 1] to demonstrate these sequences should be excluded from design basis or otherwise protected by SSCs. ONR, therefore, consider there is a gap in the submitted safety case for large un-isolable and non-isolated pipebreaks. This regulatory observation has been raised to cover this gap.**Relevant Legislation, Standards and Guidance**1. Large breaks arising in un-isolable locations (e.g. between RPV nozzles and RIVs)

Relevant guidance which relates to the need for deterministic considerations of the above break is provided by FA.5 and EMC.3 of ONR SAPs [ref. 7] along with SSG-2 [ref. 8]. FA.5 covers initiating faults that should be considered within the design basis. In particular, paragraph 628 (reproduced below) indicates that faults may only be excluded from the design basis if specific arguments for preventing that fault have been made.*628. Initiating faults identified in Principle FA.2 should be considered for inclusion in this list, but the following need not be included:**…**(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);*Principle EMC.3 then provides further guidance concerning the need for evidence to support those specific arguments (concerning high reliability/integrity). Together, the two SAPs FA.5 and EMC.3 indicate that breaks at the connection between the RPV nozzle and the RIVs should be included within the design basis unless a specific high reliability/integrity argument is made. This is consistent with SSG-2 which also indicates the need to cover a break at the connection.*3.14. The set of postulated initiating events should be defined in such a way that it covers all credible failures, including:**(a) Failures of structures, systems and components of the plant (partial failure if relevant), including possible spurious actuation*1. Large breaks arising in isolable locations with a subsequent CCF resulting in the failure of the RIVs to close

Relevant guidance which relates to the need for deterministic considerations of the above sequence is provided by FA.6 and EDR.3 of ONR SAPs [ref. 7]. In particular, FA.6 indicates that design basis sequences should typically be considered down to a sequence frequency of 1 x 10-7 pa (see extract below from paragraph 631).*Sequences with very low expected frequencies need not be included in the DBA. Judgement should be exercised in this regard, but for high hazard facilities, a fault sequence frequency of 1 x 10-7 pa would be a typical cut-off when applying design basis techniques*ONR consider that pipebreaks arising within the Isolation Condenser System with concurrent CCF of the Primary Protection System (PPS) to close RIVs, would lie above this cut-off and should be covered by deterministic considerations\*\*This is on the basis that EDR.3 (paragraph 185 extracted below) implies an allowable claim of up to 1 per 10 000 on the CCF of the PPS.*In general, claims for CCF should not be better than one failure per 100 000 demands. The figure of one failure per 100 000 demands represents a judgement by ONR of the best limit that could reasonably be supported for a simple system by currently available data and methods of analysis. A worse figure may need to be used (say 1 per 10 000 or 1 per 1000) according to the complexity and novelty of the system, the nature of threat and the capability of the equipment.***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 1x10-7 pa. This expectation is typically met by provision of a second line of protection as a backup to the principle means. ONR therefore expects diverse safety measures for pipebreaks on the ICS, where 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.

We are seeking assurances, through suitable plan(s) agreed in Step 2, on how the RP plans to address the RO action identified below. Through either existing planned work or new work packages, a description of suitable activities to cover the points identified is sought, along with timescales, standards and guidance that will be applied and criteria.**References**[1] GE-Hitachi, NEDC-34183P BWRX-300 UK GDA Chapter 15.5 - Deterministic Safety Analysis, Rev A, 6 December 2024, ONRW-2019369590-15536.[2] GE-Hitachi, BWRX-300 Safety Strategy Specification, 006N5064, Revision 6, ONRW-2019369590-18450[3] GE-Hitachi, Submission of BWRX-300 UK GDA, RQ-01763 Full Response, 14March 2025, ONRW-609516046-1070[4] GE-Hitachi, Submission of BWRX-300 UK GDA, Response to Regulatory Query (RQ)-01770, Full Response, 16 May 2025, ONRW-2019369590-20778[5] GE-Hitachi, Submission of BWRX-300 UK GDA Step 2 RQ-01870 Response, 4 April 2025, ONRW-609516046-1332[6] GE-Hitachi, NEDC-34194P BWRX-300 UK GDA Chapter 22 Structural Integrity of Metallic System Structures and Components, Rev A, 22 November 2024, ONRW-2019369590-15018 [7] ONR, Safety Assessment Principles for Nuclear Facilities, 2014 Edition, Revision 1, January 2020[8] IAEA Safety Standards, Deterministic Safety Analysis of Nuclear Plants, Specific Safety Guide, No. SSG-2 (Rev.1) |
| **REGULATORY OBSERVATION ACTIONS** |
| **RO-BWR300-004.A1 – Safety Case for large unisolable/non-isolated LOCAs**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 ICS with subsequent common cause failure of the PPS resulting in RIVs failing to close
* Structural integrity justification and granulated classification of the pressure retaining 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 [ref. 6])
* 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)
* As appropriate, demonstration of linkage between the above events, safety measures, their safety functions and performance requirements

Resolution required by '*to be determined by GE-Hitachi Resolution Plan*' |

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| **REQUESTING PARTY TO COMPLETE** |
| **Actual Acknowledgement date** (dd/mm/yy)**:** |  |
| **RP stated Resolution Plan agreement date** (dd/mm/yy)**:** |  |