REGULATORY OBSERVATION

REGULATOR TO COMPLETE

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Date sent:	28th November 2016
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Agreement of Resolution Plan required by:	20th January 2017
Resolution of Regulatory Observation required by:	*To be determined by the Hitachi-GE Resolution Plan*
TRIM Ref.:	2016/462941
Related RQ / RO No. and TRIM Ref. (if any)**:**	RQ-ABWR-0560 RO-ABWR-0023
Observation title:	PSA ALARP Demonstration and Optioneering
Technical area(s) 4. PSA	**Related technical area(s)** Internal Hazards Fault Studies Human Factors Severe Accident Analyses Civil Engineering Control & Instrumentation Radiological Protection & Level 3 PSA MoS & QA

Regulatory Observation

Summary

In response to RI-ABWR-0002 Hitachi-GE have delivered enough of the full scope UK Advanced Boiling Water Reactor (ABWR) Probabilistic Safety Analysis (PSA) to allow ONR to begin to globally evaluate the UK ABWR risk.

The objective of this Regulatory Observation (RO) is to state ONR's expectations related to the demonstration that the risk calculated by the UK ABWR PSA is As Low As Is Reasonably Practicable (ALARP).

Background

Demonstration of ALARP

During Step 3 GDA, ONR reviewed the arguments underpinning the use of the PSA to support the demonstration that the UK ABWR risk is ALARP and to support the design process. ONR's assessment identified areas that needed enhancement to meet regulatory expectations and international good practice. In particular, the review found that Hitachi-GE's approach to use of the PSA (e.g. to support the development of the design) did not meet expectations in the PSA TAG Table A1-2.9.3, A1-3.6, A1-6.2 and the Safety Assessment Principles (SAPs).

As a result ONR raised RQ-ABWR-0560 and identified RQ-ABWR-0560 as a reference of RI-ABWR-0002. Although the review was undertaken for the UK ABWR PSA for internal initiating events during operation at power, the actions of RQ-ABWR-0560 were applicable to the full scope PSA.

In September 2016, Hitachi-GE produced a preliminary Topic Report on Use of PSA in ALARP Assessment [1] to provide evidence from the PSA that the UK ABWR design follows the principles of ALARP and to identify any areas where further risk reduction may be possible as GDA Step 4 activities are completed, or during the detailed design and plant operation which follow the completion of GDA.

Due to the preliminary status of this document, ONR have not formally assessed the Topic Report. However an initial review showed that, on the basis of the information provided by Hitachi-GE, it likely will not meet ONR's expectations at this stage. This view has been shared with Hitachi-GE and Hitachi-GE is preparing to

update the report to meet ONR's expectations.

Hitachi-GE has guidance on Safety Case development [2] and on ALARP [3] which contain requirements for a thorough process for identification and evaluation of options to reduce risk. In these documents, Hitachi-GE identifies that a process should be undertaken to identify possible risk-reduction options in a systematic, auditable and comprehensive way.

Status of PSA

Hitachi-GE have produced a PSA with the following major aspects:

1. Internal Events at Power (IEAP) Level 1 [4] and Level 2 PSA [5].
2. Internal Events Spent Fuel Pool (SFP) Level 1 [6] and Level 2 PSA [7].
3. Internal Events Shutdown Level 1 [8] and Level 2 [9] PSA.
4. Fuel Route and Dropped Loads Level 1 and Level 2 PSA [10].
5. Seismic Level 1 and Level 2 PSA [11].
6. Internal Fire Level 1 and Level 2 PSA (Reactor at Power only) [12].
7. Internal Flood Level 1 and Level 2 PSA (Reactor at Power only) [13].

Delivery of the PSA models and documentation noted above has been provided in a staged manner and ONR's assessment of the PSA is ongoing. Further PSA development is expected to address the findings of ONR's assessment, and to include consideration of Internal Fire and Internal Flood during shutdown and the impact on the SFP.

A Level 3 PSA has been developed for the UK ABWR GDA; however it does not yet include consideration of Internal Fire and Internal Flood Initiating Events. The extant Level 3 PSA shows that the BSO for Target 9 [14] will not be met by the Internal Events PSA and, from the current evaluation of the Level 1 and Level 2 PSAs for Internal Fire and Internal Flood, it is expected that the global risk will significantly exceed the BSO for Target 9.

Hitachi-GE has not yet presented a comprehensive picture of the global risk calculated by the various elements of the UK ABWR PSA; a 'PSA summary report' is expected at the end of 2016.

Regulatory Expectations

ONR expects ALARP to be demonstrated, and requires evaluation of the risks and consideration of whether it would be reasonably practicable to implement further safety measures [15].

The BSOs form benchmarks that reflect modern safety standards and expectations. It is ONR's expectation that new reactors strive to meet the BSOs detailed in the Safety Assessment Principles [14] and where BSOs are not met that the risks are comprehensively and rigorously demonstrated to be ALARP.

The ALARP case should be fit for purpose. If the risks are high then the demonstration of ALARP needs to be more rigorous than if the risks are low [15].

ONR expects that the results of the PSA to be reviewed systematically to determine if improvements could be made to the design or operation of the facility to make the risks as low as reasonably practicable [16].

Following this it is ONR's expectation that there is a clear conclusion that there are no further reasonable practicable improvements that could be implemented, and therefore the risk has been reduced to ALARP [15]. The PSA is expected to have been used effectively to demonstrate that the risk associated with the design and operation of the UK ABWR is ALARP [16] and that it is reasonable to conclude that there are no further reasonable practicable improvements identified for the generic plant design during GDA.

As part of the ALARP demonstration ONR expects that plant vulnerabilities highlighted by the PSA and other areas where improvements could be made in the plant design or operation to reduce the risk should be clearly identified. This is expected to be done in a systematic, transparent and auditable way. The ALARP demonstration should consider all levels of defence in depth. The principle of defence in depth constitutes relevant good practice and is firmly embedded in ONR's SAPs.

An example of a way in which the regulatory expectations could be addressed is presented below for guidance

(this is similar to the guidance already provided in RQ-ABWR-0560); however Hitachi-GE should determine what it considers to be the best way to meet regulatory expectations.

1. Systematic review of PSA results to identify plant vulnerabilities and other aspects of the plant design where risk informed improvements could be undertaken. This for example could include:
    a. Systematic review of risk significant MCS along with, initiating events, system and basic event importance measures to identify plant vulnerabilities and other aspects where risk informed improvements to the design could be undertaken (such as measures to increase defence in depth, reduce initiating event frequencies, increase component or system reliability, increase resilience to hazards etc.).
    b. When identified vulnerabilities and other aspects are not judged representative of the plant due to conservative modelling or assumptions the level of conservatism could be estimated and information could be provided to the expected stage of design, construction or commissioning at which the conservatism could be removed.
    c. The vulnerabilities and other aspects identified could be described to aid understanding, for example describing their risk significance to estimate the potential for risk improvements.

2. Sensitivity and importance analysis for the critical safety functions and initiating events to determine the overall impact failure on the CDF and LRF (as appropriate). The scope of the initiating events to be considered and a comprehensive list of critical safety functions should be defined and justified.

    Guided by the sensitivity and importance analysis, potential improvements should be identified for further consideration. Potential improvements to increase the reliability of the critical safety functions and to improve defence in depth should be identified. Potential improvements in operator procedures related to maintaining availability of the critical safety functions should also be considered.

    Reference to existing and ongoing ALARP workstreams and demonstrations should be made if relevant.

3. Options for design changes identified in collaboration with the Hitachi-GE engineering function.
    a. Using the information and insights extracted from the PSA to develop a list of options to reduce the risks.
    b. Identify any options being considered in other areas that could have a significant impact on the results of the PSA, which have not been identified by review of the PSA results.
    c. Links to existing and ongoing ALARP demonstrations could be made if relevant.

4. Risk benefits of the options proposed examined using the full scope PSA.
    a. Links to existing and ongoing ALARP demonstrations could be made where relevant.

5. Options identified as design improvements that can contribute towards reducing risks to ALARP (or not) within GDA, and a programme for their consideration developed.
    a. If an option is considered to contribute towards reducing risks to ALARP and is to be incorporated in the UK ABWR design reference within GDA, a programme should be presented and an overview should be given of the remaining implementation making process.
    b. If an option is considered to contribute towards reducing risks to ALARP and is to be incorporated in the UK ABWR design reference after GDA, justification should be provided for deferring the implementation of the decision. It should be demonstrated that closure of GDA does not preclude the option from being incorporated into the design and that a commitment to consider the implementation of the option in the future has been made. Information should also be provided for the stage of the design process when the implementation will take place.
    c. Where consideration of options is deferred to a later stage in the design process, this should be justified. Information should be provided for the stage of the design, construction or commissioning in which the option will be considered. It should be demonstrated that closure of GDA does not preclude the option from being incorporated into the design and that a commitment to consider the option in future has been made and recorded as part of GDA.
    d. Where options are not considered for incorporation into the design, justification should be provided. This should include consideration of the limitations of the PSA and the risk calculated by the full scope PSA (i.e. including consideration of Internal Fire and Internal Flood).

It is ONR's expectation that the Hitachi-GE engineering function be involved in the identification and evaluation of options. Hitachi-GE process 'Generic Design Development Control' [17] identifies PSA as a 'Design and

Development Input' and details four steps for PSA involvement. The identified PSA insights, the resulting ALARP considerations and identified design changes are registered in the 'Issue/Assumption Register system'. The outputs from the four steps could be provided to as part of the demonstration of meeting ONR's expectations identified above - particularly extracts from the 'Issue/Assumption Register', records of the 'step two' ALARP consideration and 'Design Change Notes' for agreed design changes.

The RO Actions detailed below are anticipated to align with the four steps detailed in the Hitachi-GE process 'Generic Design Development Control' [17]. The result of Action RO-ABWR-00NN-A2 is anticipated to feed into 'step one'. The result of Action RO-ABWR-00NN-A3 is anticipated to be reached by 'step two' and 'step three'. The result of Action RO-ABWR-00NN-A4 is anticipated to be reached by 'step four'.

In relation to items 5 b and c above, ONR understands that decisions on aspects of the detailed design may not be possible as part of GDA, however where the PSA insights show that an aspect of the detailed design is risk significant it should be demonstrated that closure of GDA does not preclude risk informed design from taking place later in the design process, things such as room sizing, civil design, heat loads and electrical loads should be taken into account. Wherever possible, ONR expects that suitable design requirements have been included as part of GDA.

References:

1. Hitachi-GE, Topic Report on Use of PSA in ALARP Assessment – Current Status and Future Applications, AE-GD-0803, Revision 0, September 2016.
2. Hitachi-GE, GDA Safety Case Development Manual, XD-GD-0036, Revision 1, November 2015.
3. Hitachi-GE, GDA ALARP Methodology, XD-GD-0037, Revision 1, November 2015.
4. Hitachi-GE, Topic Report on Internal Event at Power Level 1 PSA, AE-GD-0257, Revision 4, June 2016.
5. Hitachi-GE, Topic Report on Internal Event at Power Level 2 PSA, AE-GD-0258, Revision 3, June 2016.
6. Hitachi-GE, Topic Report on Internal Event SFP Level 1 PSA, AE-GD-0589, Revision 2, August 2016.
7. Hitachi-GE, Topic Report on Internal Event SFP Level 2 PSA, AE-GD-0615, Revision 2, August 2016.
8. Hitachi-GE, Topic Report on Internal Event Shutdown Level 1 PSA, AE-GD-0573, Revision 1, June 2016.
9. Hitachi-GE, Topic Report on Internal Event Shutdown Level 2 PSA, AE-GD-0614, Revision 1, July 2016.
10. Hitachi-GE, Topic Report on Fuel Route / Dropped Loads PSA, AE-GD-0724, Revision 0, July 2016.
11. Hitachi-GE, Topic Report on Seismic PSA, AE-GD-0691, Revision 1, July 2016.
12. Hitachi-GE, Task Report 14 for Fire PSA (Fire Risk Quantification), AE-GD-0751, Revision 0, August 2016.
13. Hitachi-GE, Topic Report on Flooding PSA, AE-GD-0788, Revision 0, August 2016.
14. Office for Nuclear Regulation, Safety Assessment Principles for Nuclear Facilities, Revision 0, 2014.
15. Office for Nuclear Regulation, Guidance on the Demonstration of ALARP Nuclear Safety Technical Assessment Guide, NS-TAST-GD-005, Revision 7, December 2015.
16. Office for Nuclear Regulation, Probabilistic Safety Analysis Nuclear Safety Technical Assessment Guide, NS-TAST-GD-030, Revision 5, June 2016.
17. Hitachi-GE, Generic Design Development Control, GNQA13-0201, Revision 11, August 2016.

Regulatory Observation Actions

RO-ABWR-00NN.A1: Provide the process for systematically using the PSA to identify options to be considered to reduce the risk calculated by UK ABWR PSA to ALARP

Hitachi-GE is requested to develop and document a detailed process for using the full scope PSA and results in a systematic and thorough way to identify potential options for design improvement to reduce the risk of the UK ABWR to ALARP. If relevant processes are already in place, or are required to be interfaced with, they should be identified.

Resolution required by: To be determined by the Hitachi-GE Resolution Plan

RO-ABWR-00NN.A2: List the options identified from systematic review of the full scope PSA to be considered to reduce the risk calculated by UK ABWR PSA to ALARP

1. Hitachi-GE is requested to use the process developed to address Action 1 to systematically and thoroughly use the full scope PSA model and results to identify insights and vulnerabilities of the UK ABWR design. Hitachi-GE should then develop a list of potential options for design improvements to address the insights and vulnerabilities identified. Hitachi-GE is expected to define a suitable scope, focusing on areas where the risk is high. The development of the list of options should be documented in detail. Links to existing and ongoing ALARP workstreams should be made if relevant (for example, activities relating to resolution of RO-ABWR-0023).

2. Evidence should be provided that the Hitachi-GE engineering function have been involved in the identification of options in response to Action 2.1.

Resolution required by: To be determined by the Hitachi-GE Resolution Plan

RO-ABWR-00NN.A3: Evaluation of the risk reduction for the options identified in Action 2

1. Hitachi-GE is requested to use the full scope PSA model to evaluate the risk reduction of the options identified in Action 2. The evaluation of options should be documented in detail.

2. Evidence should be provided that the Hitachi-GE engineering function have been involved in the evaluation of the risk reduction of the options identified in Action 2.

Resolution required by: To be determined by the Hitachi-GE Resolution Plan

RO-ABWR-00NN.A4: Identify ALARP design changes to be incorporated into the UK ABWR Design Reference

1. Taking the risk reduction analysis performed to address Action 3, Hitachi-GE is requested to decide which options are reasonably practicable to be incorporated into the UK ABWR Design Reference. The decision made for each option in A2 should be documented in detail, including justification for when an option is not considered for incorporation.

2. Hitachi-GE are requested to demonstrate that changes to the design reference should be made prior to completion of GDA, or where this is not possible, how the commitment to make the change should be managed through the next stage of the licensing process and how closure of GDA does not preclude the options from being considered as part of future risk informed design activities.

Resolution required by: To be determined by the Hitachi-GE Resolution Plan

RO-ABWR-00NN.A5: PSA ALARP demonstration and optioneering programme

Hitachi-GE is requested to review and update the PSA programme to include the development of the PSA ALARP demonstration and optioneering required to address the actions in this RO.

Resolution required by: To be determined by the Hitachi-GE Resolution Plan

REQUESTING PARTY TO COMPLETE

Actual Acknowledgement date:	

RP stated Resolution Plan agreement date:	