

Hitachi-GE Nuclear Energy, Ltd.
UK ABWR GENERIC DESIGN ASSESSMENT
Resolution Plan for RO-ABWR-0046
(UK ABWR Containment Performance Analyses for Severe Accidents)

RO TITLE:	UK ABWR Containment Performance Analyses for Severe Accidents	
REVISION :	1	
Overall RO Closure Date (Planned):	29 February 2016	
REFERENCE DOCUMENTATION RELATED TO REGULATORY OBSERVATION		
Regulatory Queries	RQ-ABWR-0514	
Linked ROs	RO-ABWR-0023, RO-ABWR-0042, RO-ABWR-0048	
Other Documentation		

Scope of work :
<p>Background A critical aspect of the success criteria and fission product release characterization in a PSA is the containment performance. This performance is usually characterized by a containment capability curve that displays the best estimate performance of the containment under the spectrum of pressure and temperature challenges plus additional analyses for other possible containment challenges (e.g., hydrodynamic loads). The containment failure envelop used for the Level 2 PSA appears to be relatively restrictive in both pressure and temperature compared with typical US BWR containment failure curves. In addition, no criteria for failure are provided and no size or location of possible failures is discussed.</p> <p>Scope of Work The response to this RO is the delivery of the containment performance characterization for UK ABWR in GDA. This Resolution Plan shows some of the actions and milestones for preparation and delivery of the containment performance characterization to meet regulatory expectations described in this RO. The detailed programme of work is shown as below.</p>

Description of work:

RO-ABWR-0046.A1: Containment performance analyses model and approach

1. Hitachi-GE is requested to provide a methodology report that explains the containment model and approach that will be used for the assessment of the containment capability.
2. Hitachi-GE is requested to provide a justification that containment structural model is sufficiently detailed to support decisions regarding the identification of the containment failure location and the associated conditions of their occurrence, including but not limited to the UK ABWR structures listed in Ref.[1].

The purpose of this action is to document a methodology report that explains the containment model and approach that will be used for the assessment of the containment capability and to provide a justification that containment structural model is sufficiently detailed to support decisions regarding the identification of the containment failure location and the associated conditions of their occurrence.

Hitachi-GE will provide a methodology report that includes the following information. (Action 2.1)

- Development approach used for the assessment of the containment capability
 - a) Identification plan of the accident condition that might lead to the containment failure
 - b) Identification plan of the failure locations and failure modes (examples are shown in RQ-ABWR-0514 ^[1])
 - c) Investigation plan of failure condition
- Model description for the containment capability assessment
 - a) Justification of adequacy of the structural models

RO-ABWR-0046.A2: Pressure and Temperature Envelop

Hitachi-GE is requested to provide the documented identification of the “typical” or representative combined pressure and temperature challenges to be assessed to identify failure and size locations for the Level 2 PSA. This should include references to the supporting deterministic plant response calculations for identified severe accident types.

The purpose of this action is to show that the range of loads and combinations of loads considered to analyse the probability of containment failure in the PSA are adequate to represent the conditions of the severe accident sequences that are possible for the UK ABWR.

Hitachi-GE will provide the following information. (Action 2.2)

- Assessment of representative combined pressure and temperature challenges
 - a) Summary of containment response
 - b) Assessment of containment response
- Identification of failure and size locations for Level 2 PSA
 - a) Candidates of failure locations and size
 - b) Documentation of justification

Plant damage states are categorized into some representative sequences such as TQUV, TQUX, TB, TW, TC and AE. The plant challenge conditions due to overpressure and overtemperature are investigated based on the above representative sequences and other PDSs identified in the action to RO-ABWR-0048. For rapid pressurization event such as FCI and DCH, the plant challenge condition is investigated. A cumulative failure probability as a function of temperature and pressure is also investigated.

A draft report for this Action will be developed during the study period. This draft report will be an element of the final reporting (Action 2.8)

Description of work:

RO-ABWR-0046.A3: Negative Containment Pressure

1. Hitachi-GE is requested to provide both the criteria for evaluating the liner integrity and structural capability of components when subjected to negative containment pressures.
2. Hitachi-GE is requested to provide the identification of negative containment pressures to be considered in the assessment of the containment capability and explain how these have been determined (eg. the accident conditions that have been considered and justification of adequacy of the deterministic code use).

The purpose of this action is to show that the containment capability assessment should identify the criteria to be used for a realistic assessment of the liner, structural capability of components (e.g., hatches), and the concrete structure when subjected to the negative containment pressures.

Hitachi-GE will provide the following information. (Action 2.3)

- Criteria for evaluating the liner integrity and structural capability of components
- Basis of negative containment pressure

a) Accident condition to be considered

Pipe rupture outside the containment and PCV pressure decreasing due to containment cooling after containment venting will be considered. Need for other accident conditions to be considered will be reviewed and justified.

b) Justification of adequacy of the deterministic code use

A draft report for this Action will be developed during the study period. This draft report will be an element of the final reporting (Action 2.8)

RO-ABWR-0046.A4: Hydrodynamic Loading

1. Hitachi-GE is requested to identify accident conditions for which the temperature or water level containment conditions are outside the design basis of the containment.
2. Hitachi-GE is requested to provide analysis that shows the possible hydrodynamic loads induced on containment components and structure following conditions identified above. This should include but not be limited to the severe venting into the suppression pool when the pool is outside of technical specifications.
3. Hitachi-GE is requested to provide the approach to assess the following:
 - The ability of components and structures such as the lower drywell tunnels to survive large hydrodynamic loads generated during accident conditions.
 - Loads transmitted to the containment boundary during such events.
 - The maximum hydrodynamic loads that the containment can withstand i.e. containment walls, access tunnels, penetrations.

The purpose of this action is to show that the containment capability assessment include a demonstration of the ability of components and structures such as the lower drywell tunnels to survive large hydrodynamic loads under beyond design basis conditions. In addition, the purpose of this action is to assess loads transmitted to the containment boundary during such events and to show that the containment can withstand i.e. containment walls, access tunnels, penetrations..

Hitachi-GE will provide the following information. (Action 2.4)

- Identification of accident condition outside the design basis on temperature and water level

a) Basis for the hydrodynamic loads applied on the containment

b) Method of assessing the impact on containment

- Assessment of hydrodynamic loads induced on containment components and structure

a) SRV in late phase

b) Containment venting (spurious operation)

c) Piping break in late phase

d) Vessel breach

- Approach and assessment

a) Components and structures such as the lower drywell tunnels

b) Load transmitted to the containment boundary

c) Maximum hydrodynamic loads

Description of work:

A draft report for this Action will be developed during the study period. This draft report will be an element of the final reporting (Action 2.8)

RO-ABWR-0046.A5: Direct Debris Interaction

Hitachi-GE is requested to provide the approach used to assess the performance of the containment boundary integrity given severe accident core melt progression and RPV breach (resulting in the release of molten debris to the containment). This assessment would include the direct debris interaction with the liner (and its supporting concrete), lower drywell tunnels, and penetrations that could result in containment failure. This evaluation may require a separate model or analysis to demonstrate the boundary integrity.

The purpose of this action is to show that the containment capability assessment address the performance of the containment boundary under the postulated conditions.

Hitachi-GE will provide the following information. (Action 2.5)

- Approach and assessment
- Special treatment
 - a) Access tunnel
 - b) Liner and/or concrete
 - c) Penetrations

A draft report for this Action will be developed during the study period. This draft report will be an element of the final reporting (Action 2.8)

RO-ABWR-0046.A6: Impact of pedestal failure

- 1. Hitachi-GE is requested to provide the criteria for the pedestal failure (e.g., pressure loading or loss of concrete support) along with its basis.**
- 2. Hitachi-GE is requested to explain the containment response following pedestal failure.**

The purpose of this action is to show the criteria for the pedestal failure along with its basis and to explain the containment response following pedestal failure.

Hitachi-GE will provide the following information. (Action 2.6)

- Criteria for the pedestal failure (pressure loading, support, basis, etc.)
- Explanation of the containment response following pedestal failure
 - a) Failure mode
 - b) Evaluation of containment response

A draft report for this Action will be developed during the study period. This draft report will be an element of the final reporting (Action 2.8)

Description of work:

RO-ABWR-0046.A7: Evaluation of Other Conditions

1. Hitachi-GE is requested to identify other conditions imposed on the containment that could lead to containment failure (for example conditions could include but not be limited to subjecting the metal components to extreme temperature gradients by quenching the exterior of the components leading to cracking of high residual stressed components).
2. Hitachi-GE is requested to provide an assessment of the conditions identified above on the components for various justified severe accident time histories of pressure and temperature.

The purpose of this action is to identify other conditions imposed on the containment that could lead to containment failure.

Hitachi-GE will provide the following information. (Action 2.7)

- Identification of the conditions imposed on containment that could lead to containment failure
e.g. Failure modes include possible modes such as concrete failure, rebar failure, metal containment failure and interaction failure between concrete and metal against pressure and temperature.
- Assessment of the components in the identified condition

A draft report for this Action will be developed during the study period. This draft report will be an element of the final reporting (Action 2.8)

RO-ABWR-0046.A8: Containment performance analyses (results)

Hitachi-GE is requested to provide the containment performance analyses, including but not limited to the following :

- Examination of the DW head flange under high pressure and temperature conditions.
- Examination of the containment steel liner interface with the concrete and penetrations during severe accident conditions.
- Assessment of hydrodynamic loading on containment structural integrity (including analysis that shows the maximum hydrodynamic loads that the containment can withstand i.e. containment walls, access tunnels, penetrations).
- Assessment of negative containment pressures on the containment lines and metal components including the vapor suppression system.
- Assessment of debris effects on metallic boundary components including the liner (and the concrete providing structural support to these).

The purpose of this action is to document the analysis report of UK ABWR containment performance.

Hitachi-GE will provide an analysis report that includes the following information. (Action 2.8)

- Objective and approach
- Containment performance analysis, result and justification
 - a) D/W head flange (Flange opening behaviour, Failure mode , Failure pressure and temperature)
 - b) Containment steel liner interface with the concrete and penetration (Failure mode , Failure pressure and temperature)
 - c) Hydrodynamic loading on containment structural integrity (Stress evaluation result against Hydrodynamic loads and its margin)
 - d) Negative containment pressure (Maximum negative pressure for containment)
 - e) Debris effect on metallic boundary components

As the result of this action, the realistic basis for containment failure that is to be applicable for each of spectrum of accident will be identified considering the probability of failure at locations such as D/W head, D/W main body, W/W airspace, and W/W water space, and etc. Hitachi-GE will produce a cumulative failure probability as a function of pressure at selected temperatures and for the hydrodynamic load induced failures.

Summary of impact on GDA submissions:

<u>Related RO Actions</u>	<u>GDA Submission Document Title</u>	<u>Document ID (Document No.)</u>	<u>Submission Date to the Regulators</u>
ROA1	Methodology Report on Containment Performance Analyses Model and Approach	GA91-9201-0003-00836 (AE-GD-0490)	30-July-2015
ROA2,ROA3, ROA4, ROA5, ROA6, ROA7, ROA8	Containment Performance Analysis Report in UK ABWR	-	30-Nov-2015

Programme Milestones/ Schedule:

See attached Gantt Chart (Table 1).

* : The schedule to produce all necessary containment structural analyses required to support Level 1 PSA and Level 2 PSA update in response to RI-ABWR-002 will allow sufficient time for the results to be adequately incorporated into the updated PSA model and documentation and reviewed following Hitachi-GE QA process prior the PSA is submitted to ONR.

Reference:

Ref[1] RQ-ABWR-0514 UK ABWR structures failure modes, 29th April 2015.

Table 1 RO-ABWR-0046 Gantt Chart

Resolution Plan for RO-ABWR-0046				May							June							July							August							September							October							November							December						
UK ABWR Containment Performance Analyses for Severe Accidents				4	11	18	25	1	8	15	22	29	6	13	20	27	3	10	17	24	1	7	14	21	28	5	12	19	26	2	9	16	23	7	14	21	28																						
Level	Action Title	Start	Finish																																																								
1	Regulator's issue of RO	1-May-15	30-Jul-15	[Green bar from May 1 to July 30]																																																							
2	Preparation of Submissions and Closure of RO Actions																																																										
2.1	Action 1: Containment performance analyses model and approach	25-May-15	30-Jul-15	[Green bar from May 25 to July 30]																																																							
2.2	Action 2: Pressure and Temperature Envelop	1-Jun-15	30-Sep-15	[Green bar from June 1 to September 30]																																																							
2.3	Action 3: Negative Containment Pressure	10-Aug-15	30-Sep-15	[Green bar from August 10 to September 30]																																																							
2.4	Action 4: Hydrodynamic Loading	1-Jun-15	30-Oct-15	[Green bar from June 1 to October 30]																																																							
2.5	Action 5: Direct Debris Interaction	10-Aug-15	30-Sep-15	[Green bar from August 10 to September 30]																																																							
2.6	Action 6: Impact of pedestal failure	1-Sep-15	30-Oct-15	[Green bar from September 1 to October 30]																																																							
2.7	Action 7: Evaluation of Other Conditions	1-Jun-15	31-Jul-15	[Green bar from June 1 to July 31]																																																							
2.8	Containment Performance analysis (results)	1-Jun-15	13-Nov-15	[Green bar from June 1 to November 13]																																																							
3	Regulator's Closure of RO	1-Dec-15	29-Feb-16	[Green bar from December 1 to February 29, 2016]																																																							
RO-23	Additional SA Analysis for Unmitigated Sequence (TW)	1-Aug-15	1-Sep-15	[Green bar from August 1 to September 1]																																																							
RO-42	Update of Level 1 PSA	6-Jul-15	30-Sep-15	[Green bar from July 6 to September 30]																																																							
RO-23	Additional SA Analysis for Mitigated Sequence and Source Term	1-Nov-15	1-Dec-15	[Green bar from November 1 to December 1]																																																							
RO-48	Update of Level 2 PSA	10-Aug-15	30-Dec-15	[Green bar from August 10 to December 30]																																																							