REGULATORY OBSERVATION

REGULATOR TO COMPLETE

RO unique no.:	RO-ABWR-0046
Date sent:	20th April 2015
Acknowledgement required by:	08th May 2015
Agreement of Resolution Plan required by:	14th May 2015
Resolution of Regulatory Observation required by:	*To be determined by the Hitachi-GE Resolution Plan*
TRIM Ref.:	2015/158214
Related RQ / RO No. and TRIM Ref. (if any)**:**	RQ-ABWR-0514 2015/158098
Observation title:	UK ABWR Containment Performance Analyses for Severe Accidents
Technical area(s) PSA Severe Accident Analyses Civil Engineering Structural Integrity	**Related technical area(s)** Level 3 PSA

Regulatory Observation

Summary

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. The objective of this Regulatory Observation (RO) is to state ONR's expectations related to the containment performance characterization and its documentation.

Background and Regulatory Expectations

The Level 2 PSA identifies, evaluates and quantifies loads on the containment structure that can occur as a result of a severe accident. This is a critical aspect of the success criteria and fission product release characterization in a PSA. In order to assess the probability that a given load will result in failure of the containment structure, knowledge of the capacity of the structure to withstand loads is needed. This performance is usually characterized by a containment capability curve that displays the best estimate performance of the containment (eg. with consideration of the uncertainties represented by the probability distribution) 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 is presented in Figure 5.2-1 of UK ABWR Level 2 PSA (Ref.1). However, it 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 are discussed.

The objective of this Regulatory Observation (RO) is to state ONR's expectations related to the containment performance characterization and its documentation. ONR expectation is that the Requesting Party (RP) containment capability assessment to support the PSA should consider the following potential challenges to the containments:

- Pressure and temperature envelop

- Negative containment pressure
- Hydrodynamic loading basis
- Pedestal failure implication
- Direct debris interaction
- Other possible conditions

ONR expectation is that a containment model is used to identify the containment failure locations; and the associated criteria that are violated. The containment model, code and inputs used to analyse the containment structural response should be suitable (e.g., a finite element analysis that examines performance beyond the elastic regime) and encompasses sufficient detail to allow the identification of failure modes associated with the UK ABWR structures. Further details are provided in Ref.3.

Pressure and Temperature Envelop

Severe accident challenges include combined quasi-static temperature and pressure conditions that can cause the containment boundary to fail. Therefore, the ability to define these conditions and the associated failure criteria are critical inputs to the PSA.

ONR expectation is 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. Analyses should be thoroughly documented and fully traceable, including the identification of the “typical” or representative combined pressure and temperature challenges to be assessed by using results of deterministic plant response calculations for identified severe accident types.

For certain rapid pressurization events, the MAAP code may not adequately represent the peak containment pressure (eg. this may include cases with vapor suppression failure).

Negative Containment Pressure

In addition to containment conditions that can cause pressurization events, there are also postulated beyond design basis events that could lead to negative containment pressure. Such conditions may result in liner disruption, flaw development and propagation, leakage to behind the liner, and ultimately containment leakage.

ONR expectation is 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. A realistic negative failure pressure and location(s) should be part of the assessment. The imposed negative containment pressures should include and adequate range of accident conditions using an acceptable deterministic code. These accident conditions should include but not be limited to a severe accident pressurization followed by containment vent that removes a substantial portion of the non-condensables and then vent closure and initiation of sprays injection causing rapid condensation.

Hydrodynamic Loading

There is a possibility that temperature or water level containment conditions are outside the design basis of containment. For such conditions, it appears to be certain level of uncertainty regarding the structural responses.

ONR expectation is that the containment capability assessment will include a demonstration of the ability of components and structures such as the lower drywell tunnels to survive large hydrodynamic loads (for example as generated during RPV breach or a large LOCA during core melt progression). In addition, loads transmitted to the containment boundary during such events also need to be assessed. ONR expectation is that the RP provides analysis that shows the maximum hydrodynamic loads that the containment can withstand i.e. containment walls, access tunnels, penetrations.

Pedestal Failure Implications

As a result of Fuel Coolant Interaction (FCI), Direct Containment Heating (DCH), or Molten Core Concrete

Interaction (MCCI), the lower drywell pedestal could be postulated to fail. ONR expectations are the following:

- The criteria for the pedestal failure (e.g., pressure loading or loss of concrete support) needs to be identified along with its basis.
- Given that the criteria is exceeded, the description of the subsequent containment response that leads to failure should be identified (eg. given an FCI with pedestal failure is the expectation that the containment failure occurs due to pedestal collapse and penetration disruption at the containment boundary)

Direct Debris Interaction

Given severe accident core melt progression, an RPV breach would result in the release of molten debris to the containment. It is ONR expectation that the containment capability assessment address the performance of the containment boundary under the postulated conditions. This assessment would include the direct debris interaction with the liner, 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.

Evaluation of Other Conditions

It is ONR expectation that other conditions imposed on the containment that could lead to containment failure are identified. Such conditions could include subjecting the metal components to extreme temperature gradients by quenching the exterior of the components leading to cracking of high residual stressed components. An assessment of these other imposed conditions on the components for various severe accident time histories of pressure and temperature are considered important if unusual or unique accident management actions are to be taken.

References:

1. Internal Event Level 2 PSA at-power, GA91-9201-0001-00103 Rev. 1.
2. Severe Accident Phenomena and Severe Accident Analysis, GA91-9201-0001-00024 Rev. D.
3. RQ-ABWR-0514 UK ABWR structures failure modes, 29th April 2015.

Regulatory Observation Actions

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.3.

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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 suporting deterministic plant response calculations for identified severe accident types.

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

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).

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

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.

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

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.

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

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.

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

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.

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

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).

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:	