

<b>REGULATORY OBSERVATION</b>	
<b>REGULATOR TO COMPLETE</b>	
<b>RO unique no.:</b>	RO-ABWR-0059
<b>Date sent:</b>	26 <sup>th</sup> June 2015
<b>Acknowledgement required by:</b>	20 <sup>th</sup> July 2015
<b>Agreement of Resolution Plan Required by:</b>	<i>To be determined by the Hitachi-GE resolution plan</i>
<b>Resolution of Regulatory Observation required by:</b>	<i>To be determined by the Hitachi-GE resolution plan</i>
<b>TRIM Ref.:</b>	2015/239172
<b>Related RQ / RO No. and TRIM Ref. (if any):</b>	RO-ABWR-0023.A4 TRIM 2014/314434 RO-ABWR-0046 TRIM 2015/158214
<b>Observation title:</b>	Provision of Water Cooling for the RCCV Drywell Head of the UK ABWR
<b>Technical area(s)</b> 12. Structural Integrity	<b>Related technical area(s)</b> 02. Civil Engineering 05. Fault Studies 18. Severe Accidents 04. PSA
<b><i>Regulatory Observation</i></b>	
<b>SUMMARY</b>	
<p>The drywell head forms part of the RCCV (Reinforced Concrete Containment Vessel) containment which, in an event such as a LOCA (Loss of Coolant Accident), will form the barrier against the release of radioactivity to the environment. In a severe accident scenario, HGNE plan to flood the cavity above the drywell head, to keep the flange of the head cool.</p> <p>HGNE have presented data and analysis aimed at demonstrating the structural integrity, and hence achievement of containment function, of the DW head under the Pressurised Thermal Shock (PTS) transient imposed during external cooling. The current drywell head design does not include Post Weld Heat Treatment (PWHT) of the structural welds above the flange region. Consequentially, under the combination of loadings arising from the internal pressure, the PTS transient and non-stress relieved welds the margin between the imposed SIF and the fracture toughness is likely to be significantly reduced.</p> <p>There would be increased confidence in the structural integrity of the Dry Well (DW) head under severe accident conditions if the overall imposed SIF from the combination of the residual and thermal stress is reduced. HGNE's current approach does not give full consideration to the potential options to achieve this and whether or not it is reasonably practicable to implement one or more of those options.</p> <p>ONR's expectations for HGNE's justification are aligned with other disciplines in that ONR expects HGNE to:</p> <ol style="list-style-type: none"> <li>1. Identify options to secure the Drywell head containment function and hence afford additional protection to workers and the public under external cooling during a severe accident;</li> <li>2. Evaluate the benefits and dis-benefits associated with those options;</li> <li>3. Provide a robust demonstration to justify whether or not it is reasonably practicable to implement one or more options to show that the risks relating to the structural integrity of the Drywell head under external cooling during severe accident conditions are reduced SFAIRP (So Far As Is Reasonably Practicable).</li> </ol> <p>This RO is raised to make clear ONR's expectations with regard to HGNE's decision making with respect to potential proposals to provide additional confidence in the structural integrity of the Drywell head during severe accident conditions.</p>	

**BACKGROUND**

The drywell head forms part of the RCCV containment structure which, in an event such as a LOCA, will form the barrier against the release of radioactivity to the environment. The integrity of the RCCV under severe conditions is therefore important for the protection of workers and the public. The majority of the RCCV containment structure is of concrete construction, but the drywell (DW) head is metallic. The DW head is a large torispherical closure of internal diameter 10.3m, which is bolted to the RCCV.

Following the events of 2011, the Fukushima Daiichi accidents demonstrated that DW head seals may be susceptible to leakage of hydrogen and fission products due to a combination of high temperatures and high containment pressures. To mitigate this, HGNE propose to flood the DW head flange area to prevent overheating. The application of cooling water and subsequent differential cooling, results in a pressurised thermal shock (PTS), to the DW head.

HGNE have presented data and analysis aimed at demonstrating the structural integrity and hence achievement of containment function of the DW head under the PTS transient [1]. The PTS evaluation was undertaken in accordance with Japanese Rules on Fitness-For-Service for Nuclear Power Plant [2]. The stresses due to cooling of the DW Head were evaluated using conservative inputs; water temperatures of 0°C and 20°C an internal pressure and temperatures of 620KPa and 250°C respectively.

In response to ONR, Hitachi GE has undertaken additional work to establish the limiting location and magnitude of the stresses and hence imposed Stress Intensity Factors (SIF). The assessment demonstrates that the resulting SIFs for large postulated ¼ wall thickness 6:1 aspect ratio defects are below the fracture toughness by a margin of about 2. However, the current DW head design does not include Post Weld Heat Treatment (PWHT) of the structural welds above the flange region. Residual stresses make a significant contribution to the imposed SIF. As a consequence under the combination of loadings arising from the internal pressure, the PTS transient and non-stress relieved welds the margin between the imposed SIF and the fracture toughness is significantly reduced (approximately 1.4).

There would be increased confidence in the structural integrity of the DW head under severe accident conditions if the overall imposed SIF from the combination of the residual and thermal stress is reduced. HGNE's current approach does not give full consideration to potential options which include:

- PWHT of the DW head region above the flange,
- engineered provision to deliver cooling water to the DW head but avoiding ingress to the high residual stress regions,
- changing the DW head material,
- Operating with a pre-flooded cavity,
- heating the cooling water,
- a combination of these measures.

HGNE have indicated that PWHT of the DW head is straightforward. The implementation of PWHT would bring other safety benefits. In particular, although delivery of the cooling water is still required, the option provides more flexibility for the design of the delivery system along with providing contingency to implement other means should the engineered route not be available. In contrast, on its own, engineered provision to limit delivery of the cooling water to the flange area of the DW head may involve designing new features into the RCCV and may be more problematic. The current method envisaged involves filling the annulus around the DW head flange. Overfilling and wetting of the non-stress-relieved area of the drywell head, is claimed to be avoided by draining water through a tortuous route between concrete plugs in the RCCV. However, there is only a 25mm margin between this proposed water level and the lower limit of the non-stress-relieved section. ONR is therefore not confident there is an adequately engineered method of delivery of cooling water to avoid inducing additional thermal stresses in non-stress relieved regions of the DW head during a severe accident.

This RO is therefore raised to make clear ONR's expectations with regard to HGNE's decision making with respect to potential proposals to provide additional confidence in the structural integrity of the DW head during a severe accident. There are a number of options available to reduce risk, ONR expects Hitachi GE to consider these options or their combination and to show the risks to delivery of the containment function have been reduced SFAIRP.

**REGULATORY EXPECTATIONS**

This RO has been raised by the structural integrity discipline, but its resolution is important to other disciplines, notably, civil engineering, severe accidents, fault studies, and PSA. ONR's expectations for Hitachi-GE's justification are aligned, in that ONR expects:

- HGNE to, identify options that would provide additional confidence in the structural integrity of the DW head and hence achievement of the containment function under external cooling during severe accident conditions.
- HGNE to undertake optioneering considering the benefits and dis-benefits of implementing those options
- HGNE to provide a robust demonstration to justify whether or not it is reasonably practicable to implement one or more options to show that the risks relating to the structural integrity of the DW head under external cooling under severe accident conditions are reduced SFAIRP.

When considering the above, ONR would expect HGNE to:

- consider all relevant risks related to the implementation of the options, for example:
  - a. additional penetrations in the RCCV;
  - b. testing and maintenance activities;
  - c. the reliability of the delivery provision.
- to give consideration to the broader safety benefits of the options e.g. diversity in delivery, overall risk reduction;
- provide evidence of the criteria used in decision making and option selection, and;
- provide evidence of gross disproportion in terms of cost (time, trouble or money) for options not selected.

Therefore, ONR's assessment of the response(s) to this RO will consider the structural integrity aspects, but will also take cognisance of the views of other disciplines including for example, civil engineering, severe accidents, fault studies and PSA (other internal hazards). ONR therefore expects a similar, coordinated approach, to be adopted by HGNE.

ONR recognises that the DW head is not classified as either VHI or HI by HGNE. ONR will therefore adopt a proportionate approach in assessing HGNE's proposals. To form a judgement on the adequacy of the response to this RO, ONR's principal source of standards and guidance will be the Safety Assessment Principles (SAPs) [3], in some cases supplemented by the relevant Technical Assessment Guide (TAG) e.g. [4].

For structural integrity, the engineering principles and associated guidance covering metallic components, EMC.5 and EMC.23, are particularly pertinent:

- EMC.5: *It should be demonstrated that components and structures important to safety are both free from significant defects and are tolerant of defects.*
- EMC.23: *For metal pressure vessels and circuits, particularly ferritic steel items, the operating regime should ensure that they display ductile behaviour when significantly stressed.*

To be able to provide an adequate response to this RO, in undertaking the above work, ONR would expect:

- HGNE to consider all relevant Worldwide Operating Experience Feedback (OPEX);
- HGNE to clearly state the applicability, or otherwise, of the above Worldwide OPEX to the UK ABWR design.

**References:**

- [1] DJ-GD-0076R1 – Evaluation of Pressurised Thermal Shock (PTS) for Drywell Head of RCCV, March 2015  
 [2] JSME S NA1-2008 - Rules on Fitness-For-Service for Nuclear Power Plant  
 [3] Safety Assessment Principles for Nuclear Facilities – Revision 1, HSE, 2006.  
 [4] NS-TAST-GD-016 – Integrity of Metal Components and Structures – Revision 4, ONR, March 2013.

**Regulatory Observation Actions**

**RO-ABWR-0059.A1** – HGNE to provide a robust justification to demonstrate the structural integrity and hence achievement of the containment function for the DW head under external cooling during severe accident conditions.

ONR's expectations for the structural integrity and other disciplines for HGNE's justification are aligned, in that ONR expects:

- \* HGNE to identify options to secure the DW head containment function and hence afford additional protection to workers and the public under external cooling during a severe accident;
  
- \* HGNE to evaluate the benefits and dis-benefits associated with those options;
  
- \* HGNE to provide a robust demonstration to justify whether or not it is reasonably practicable to implement one or more options to show that the risks relating to the structural integrity of the DW head under external cooling during severe accident conditions are reduced SFAIRP.

**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:**