REGULATORY OBSERVATION

REGULATOR TO COMPLETE

RO unique no.:	RO-ABWR-0004
Date sent:	23rd March 2016
Acknowledgement required by:	15th April 2016
Agreement of Resolution Plan Required by:	*To be determined by Hitachi-GE Resolution Plan*
Resolution of Regulatory Observation required by:	*To be determined by Hitachi-GE Resolution Plan*
TRIM Ref.:	2016/126589
Related RQ / RO No. and TRIM Ref. (if any)**:**	N/A
Observation title:	Material/Forging/Weld/Clad Specifications for RPV Pressure Boundary
Technical area(s) 12. Structural Integrity	**Related technical area(s)** 9. Reactor Chemistry

Regulatory Observation

The Reactor Pressure Vessel (RPV) will be made from a number of low alloy ferritic steel forgings. These forgings will be subsequently welded together and clad to form the main pressure boundary of what will be a Very High Integrity Component (VHIC). Commensurate care will be needed to specify and control the manufacture of these forgings and the construction of this component.

For the forgings the detailed chemical specifications, forging processes, and quench and temper heat treatments are important in ensuring that they have tensile and toughness properties which exceed the minimum specified reasonably well throughout the thickness of the forging, and ensuring that through life properties are adequately maintained - for example that neutron irradiation embrittlement is minimised. Similarly careful control of welding and cladding material specifications and heat treatment processes will then be required to ensure the quality of the finished vessel.

Whilst the material specifications provided in the nuclear pressure vessel design codes will define the basis for these parameters, ONR's experience has shown that it is necessary for the Requesting Party to understand the detailed interaction of these parameters in order to apply controls over and above those specified in the design codes to ensure satisfactory finished forgings and vessel.

Examples of the types of evidence expected are:

1. Chemical Composition of Forgings:

The detailed material composition for forgings, based on the design code specification along with any additional controls, and a justification of why these limits will achieve the necessary initial and through life properties, and necessary homogeneity.

This justification should explain the basis for the limits and how these will affect aspects such as:

- The microstructure and physical properties of the steel in the as-forged and heat-treated conditions;
- The cleanliness of the steel, and other generic indicators of steel quality;
- The susceptibility of the material to forging-related defects;
- The development of the microstructure and properties following welding and/or cladding;

- The susceptibility to radiation-embrittlement and other irradiation degradation mechanisms;

- The susceptibility to thermal-embrittlement and other thermal degradation mechanisms.

This justification should consider setting compositional limits on:

- Carbon, Manganese, Molybdenum, Nickel, Cobalt, Chromium, Copper, Vanadium, Aluminium, Titanium, Niobium (plus tantalum), Arsenic, Antimony, Boron, Tin, Calcium, Sulphur, Phosphorus, Silicon, Hydrogen and Nitrogen;

- plus any other elements considered pertinent to control of properties.

2. Casting and Forging Processes:

The details of the casting and forging processes, an explanation of how these will be controlled and a justification of why they are adequate to achieve the necessary homogeneity and properties.

This will potentially consider :

- Whether the steels will be fully-killed and confirmation of the process for de-oxidation;

- Ingot casting practice and how much material is discarded and from where (to remove segregation or inclusions);

- The degree of forging reduction achieved in manufacture of the various forged parts;

- The heat treatment sequences performed during manufacture;

- Mechanical property testing (tensile, Charpy, fracture toughness etc): application, property expectations and use of scatter in demonstrating adequacy of properties and homogeneity.

3. Welding and Cladding Processes:

The detailed weld and clad material compositions and explanation of welding and cladding processes, including thermal controls, will be needed. There should be a justification of how these controls will achieve the necessary initial and through-life properties and degradation resistance, plus how these controls will lead to welds with suitable levels of initial integrity, both in terms of materials properties and defect sizes and distributions.

Evidence might typically include discussion of:

- Proposed welding processes and expected defect occurrence rates for selected processes;

- Compositional controls for the weld and cladding materials, including where these need to be controlled beyond code requirements

- Thermal and parametric controls, and how these affect the final product through-life;

Regulatory Observation Actions

Action 1.1

Regarding Materials compositions, HGNE should provide evidence that:

- Relevant Good Practice regarding Materials compositions has been considered fully, notably from previous GDAs.
- Irradiation Embrittlement surveillance programmes are adequate to mitigate the risk of irradiation embrittlement through-life.

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Action 1.2

Regarding Casting and Forging, HGNE should provide evidence that:.

- Operational Experience (OPEX) from world nuclear plant, especially in the field of forging quality control, has been captured and measures implemented to prevent recurrences for the UK ABWR.
- Evidence that the test specimens included in the materials qualification process will meet ONR's expectations in terms of being representative.

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Action 1.3

Regarding Welding and Cladding, HGNE should provide evidence that:.

- How welding processes can be considered to be ALARP in terms of defect occurrence rates.

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REQUESTING PARTY TO COMPLETE

Actual Acknowledgement date:	
RP stated Resolution Plan agreement date:	