Hitachi-GE Nuclear Energy, Ltd.
UK ABWR GENERIC DESIGN ASSESSMENT
Resolution Plan for RO-ABWR-0035
Robust justification for the materials selected for UK ABWR

RO TITLE:	Robust justification for the materials selected for UK ABWR	
ACTION:	ROA-RO-ABWR-0035. A1, A2, A3, A4, A5, A6, A7 and A8.	
REVISION:	4	
Overall RO Closure Date (Planned):		Date (30 September 2017)
REFERENCE DOCUMENTATION RELATED TO REGULATORY OBSERVATION		
Regulatory Queries:	RQ-ABWR-0103, RQ-ABWR-1087, RQ-ABWR-1111, RQ-ABWR-1324, RQ-ABWR-1327, RQ-ABWR-1329, RQ-ABWR-1330, RQ-ABWR-1332, RQ-ABWR-1334, RQ-ABWR-1339, RQ-ABWR-1342, RQ-ABWR-1346, RQ-ABWR-1453, RQ-ABWR-1455, RQ-ABWR-1458, RQ-ABWR-1461, RQ-ABWR-1465	
Linked ROs:	RO-ABWR-0006 – Source Terms, ONR/EA, April 2014, TRIM 2014/156113 [now closed] RO-ABWR-0034 – Demonstrating the inclusion of a 'bottom drain line' in the UK ABWR design achieves inherent safety and reduces risks SFAIRP, ONR/EA, January 2015, TRIM 2014/460897 [now closed] RO-ABWR-0072 – Suitable and sufficient consideration of chemistry control during UK ABWR commissioning, ONR/EA, August 2016, TRIM 2016/322866	
Other Documentation:	-	

Scope of work:

Background

The choice of materials for each System, Structure and Component (SSC) of a nuclear reactor is influenced by many competing factors, including:

- the functional requirements of the SSC;
- the tolerance/degradation of the SSC in its operating 'environment', and/or;
- the potential hazards and risks, which must be either eliminated, reduced or controlled.

Considering the above factors, and potentially others, it is clear the justification of the most appropriate material selected for each SSC requires a balance to be struck. In reaching that balance, there should be a robust demonstration that the relevant risks have been considered and reduced So Far as is Reasonably Practicable (SFAIRP).

Early in GDA of the UK ABWR, Hitachi-GE provided some information related to material choices for the design. The information received in the submissions was relatively high-level principles, and were best described as design philosophy documentation.

As Step 3 of GDA progressed Hitachi-GE planned to make several further, more detailed, submissions for specific SSCs, specifically to develop the structural integrity aspects of the safety case for UK ABWR.

Hitachi-GE's plan was that these submissions would focus on those SSCs with the highest level of integrity claims. This approach meant that the justification of materials selected for UK ABWR would be focused on those SSCs where the consequences of failure were greatest. Wider consideration and justification of the materials selected for other SSCs, whose integrity claims may be lower, but the SSC still makes an important contribution to nuclear safety is,

however, still necessary to meet ONR's expectations.

Hitachi-GE's approach at that time did not take full consideration of either:

i. the need to adequately justify materials selected for components below Very High Integrity (VHI);
ii. the need to balance the requirements of structural integrity, reactor chemistry and radiation protection. To be able to show that, on balance, the relevant risks have been reduced SFAIRP, the requirements of these, and potentially other disciplines; need to be factored in to the justification for the materials selected for UK ABWR.

The first revision of this RO was therefore raised to make clear ONR's expectations regarding Hitachi-GE's justification of the materials selected for UK ABWR. Hitachi-GE has now submitted a large number of submissions that largely addresses the original intent, as outlined above, of this RO. Despite this, ONR's assessment has revealed several concerns regarding Hitachi-GE's overall safety case for the materials selected for the UK ABWR. This RO has therefore been updated to add further actions which seek to address these concerns, which have arisen from ONR's on-going assessment. These Actions are safety case gaps which need to be adequately addressed during the remainder of Step 4 of GDA.

Scope of Work

Hitachi-GE recognise the gaps between ONR's expectations and the information provided in the suite of Material Selection Reports, and outlines the measures to fill the gaps in this resolution plan.

This RO has been raised jointly by the reactor chemistry and structural integrity topics. ONR's expectations in both these disciplines for Hitachi-GE's justification are aligned, in that ONR expects Hitachi-GE to;

- Make materials selection and safety justifications for all UK ABWR SSCs that are proportionate to the significance of identified SSCs in maintaining nuclear safety;
- Consider the nature, severity and likelihood of materials degradation in UK ABWR;
- Make a robust demonstration, showing that risks relating to materials degradation for UK ABWR are reduced SFAIRP;
- Show that all the relevant risks related to the 'degradation' and through-life integrity of the SSC in question have been considered, for example:
    a. loss of integrity;
    b. loss of performance;
    c. the generation and transport of radioactivity;
- Demonstrate how other options to eliminate, reduce, or mitigate those risks have been considered;
- Identify and document those options;
- Provide robust 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.

Hitachi-GE have submitted several material selection reports to meet the above expectations. The following work has been undertaken and is presented in the suite of submissions:

- Hitachi-GE has a depth of experience of manufacture and operation of BWRs and ABWRs. As for design and manufacture of Japanese BWR and ABWR, Hitachi-GE have complied with Japan Society of Mechanical Engineers (JSME) code which has similar design and material specification systems to American Society of Mechanical Engineers (ASME) code to design SSCs and select materials in consideration of Nuclear Safety. Applied materials for the UK ABWR have been determined according to ASME code. The applicable SSC sections have been clarified in the submissions.

- Materials have generally been selected according to the guidelines described in the Material Selection Report [1], taking into consideration design requirements, material degradation, manufacturability, inspection requirements, radiological risks, etc. Material choice and OPEX of Japanese BWRs and ABWRs that have maintained nuclear safety for a long term provide important Relevant Good Practice (RGP), in addition to monitoring results against degradation in existing plants. These are considered as RGP for material selection and have been considered as baseline material choices in the material selection assessments.

- Relevant worldwide OPEX regarding materials degradation issues has been accessed and considered during optioneering. Key references concerning materials degradation issues of relevant worldwide OPEX include the International Generic Aging lessons learned (I-GALL) report [2] of IAEA, the Generic Aging lessons learned (GALL) report [3] of US NRC and EPRI reports [4]. Material degradation issues of all relevant worldwide OPEX Hitachi-GE can access have been considered and are referred to where appropriate in the suite of material selection reports.

- SSCs of all classes from UK Class 3 through to VHI have been considered against operating environment, risks, material degradations and selected materials, with the level of rigour intended to be commensurate to the safety concerns associated with the component. This has involved identifying whether known integrity issues exist or there is potential for the release of detrimental materials leading to radiological and /or structural integrity risks downstream.

- Where the operating environment, predicted material degradations, design requirement, release of detrimental material etc. are equivalent for a number of SSCs, then consideration has been given to grouping these SSCs under the most bounding conditions. Material selection has been carried out for these grouped SSCs to demonstrate the material choice is SFAIRP.

- Hitachi-GE has provided the evidence necessary to support the claims made in the UK ABWR safety case regarding material risks and importantly include an indication of what residual risks may remain, their safety significance, how likely they may be or where they may occur when considering UK ABWR as a whole.

- Any differences between J ABWR and UK ABWR, such as Reactor Chemistry, have been considered for material selection.

- Weld metals have been optimised according to RGP for the base metals to which they are associated, including dissimilar metal welds. General considerations of the welding procedures have been described.

Whilst the suite of material selection submissions provided since the previous revision of this RO are considered to largely address the original intent, ONR's assessment has revealed several concerns regarding Hitachi-GE's overall safety case for the materials selected for the UK ABWR.

The scope of work associated with this RO is therefore to address the updated and further actions which seek to address these concerns, which have arisen from ONR's on-going assessment. These Actions are safety case gaps which need to be adequately addressed during the remainder of Step 4 of GDA.

Detailed documentation is described in the Description of work. This Resolution Plan describes Hitachi-GE's current plan to address the Regulatory Observation.

Description of work:

This section describes the work that Hitachi-GE plan to undertake to address the action identified in the RO. The detailed programme is included in Table 1.

The first revision of this Regulatory Observation (RO) was raised to make clear ONR's expectations regarding Hitachi-GE's justification of the materials selected for UK ABWR.

Hitachi-GE has now provided a large number of submissions that largely addresses the original intent, as outlined above, of this RO. Despite this, ONR's assessment has revealed several concerns regarding Hitachi-GE's overall safety case for the materials selected for the UK ABWR. This RO has therefore been updated a number of times to add further actions which seek to address these concerns, which have arisen from ONR's on-going assessment. These Actions are safety case gaps which need to be adequately addressed during the remainder of Step 4 of GDA.

The sections below describe the specific work that will be undertaken in support of ROA closure. In particular, Hitachi-GE will ensure all relevant RQs are appropriately addressed, and impacted submissions are revised prior to GDA closure.

ACTION ROA-RO-ABWR-0035.A1.1 - *Hitachi-GE to provide a robust justification for the materials selected for UK ABWR.*

There is a specific deliverable which shows the demonstration of justification of the appropriate materials selected for UK ABWR including:

- To make materials selection and safety justifications for all UK ABWR SSCs that are proportionate to the significance of identified SSCs in maintaining nuclear safety;
- To consider the nature, severity and likelihood of materials degradation in UK ABWR;
- To make a robust demonstration, showing that risks relating to materials degradation for UK ABWR are reduced SFAIRP.

The following methodology has been applied during production of the suite of material selection submissions in support of the previous revision of RO-ABWR-0035 to show the above expectations have been met:

STEP 1: Listing

All SSCs from UK Class 3 through VHI involved in Nuclear Safety have been listed including the following:

- UK ABWR Selected Material (according to ASME Code, Section II in reference to JSME Code);
- SSC;
- Classification;
- Operating environments;
- Risks and degradations;
- OPEX;
- Reason for the material selected.

The list has been provided in the Appendix of the revised Material Selection Report.

STEP 2: Screening

A process has been applied to allow an initial grouping of components with similar operating environments, functionality, known material degradation mechanism, etc. An appropriate material was initially down selected for the grouped SSCs.

STEP 3: Detailed SSC Material Selection

SFAIRP justification of materials selection has been demonstrated for the representative SSCs (according to the groups, where possible) based on STEP 2 in accordance with the following procedure. Where appropriate it is demonstrated for some safety significant SSCs individually.

STEP 3-1: Hitachi-GE have considered risks related to the degradation and through-life integrity of the SSCs. Materials degradation issues of worldwide OPEX are summarised in the International Generic Aging lessons learned (I-GALL) report [2] of IAEA, the Generic Aging lessons learned (GALL) report [3] of US NRC and EPRI reports [4]. Hitachi-GE have considered these degradation issues, other known integrity issues, and the potential for release of detrimental materials leading to radiological and /or structural integrity risks downstream. Hitachi-GE regard increase of on/off site dose rate due to failure of SSCs or material change as dominant risks.

STEP 3-2: Hitachi-GE have considered whether other options to eliminate, reduce, or mitigate those risks are available. Material choice and OPEX of Japanese BWRs and ABWRs that have maintained nuclear safety for a long time provide RGPs. There are also monitoring results against degradation in existing plants. This Japanese RGP and additional worldwide OPEX has been considered during material selection optioneering.

During the material selection SFAIRP evaluation, a Hydrogen Water Chemistry (HWC) with Noble Metal Chemical Addition (NMCA) and Depleted Zinc Oxide (DZO) reactor chemistry regime has been assumed, as opposed to NWC used in current Japanese ABWRs. Other differences between the J ABWR and UK ABWR that could impact material selection have also been assessed.

STEP 3-3: Hitachi-GE have performed a SFAIRP evaluation for the material selection options captured in STEP 3-2 and provided robust evidence of the criteria used in decision making and option selection in reference to "Reducing risk, protecting people" [5]. Hitachi-GE have described the benefits and detriments of each SSC material option against considered risks, taking account of OPEX, degradation issues, release of detrimental materials, radiological dose, design requirements, procurement availability, manufacturability, inspectability, Code compliance and so on.

STEP 3-4: Hitachi-GE have provided evidence of gross disproportion in terms of cost (time, trouble or money) and balance of risk, where required, for any reasonably practicable options not selected. Hitachi-GE have considered a gross disproportion factor in accordance with "Guidance on the Demonstration of ALARP" [6].

The ONR have assessed the suite of material selection reports provided in response to the previous revision of this RO, and have raised a number of concerns regarding Hitachi-GE's overall safety case for the materials selected for the UK ABWR. Specific concerns, and further actions deemed necessary to address them, have been raised as additional ROAs. The work previously undertaken is expected to close out this ROA.

ACTION ROA-RO-ABWR-0035.A1.2 – *Hitachi-GE are also required to demonstrate that the response(s) to this RO will be adequately captured within the safety and environmental cases for UK ABWR*.

Hitachi-GE will identify all the impacted safety and environmental submission documents that will be affected by the RO e.g. PCSR, GEP, Master Document Submission List, Design Change Documentation, DRP, Plant Lifecycle Report, Integrated Waste Strategy etc. and implement the changes in accordance with its Commitments Capture Procedure when it updates its documentation.
The submissions have captured the response to the ROA.

ACTION ROA-RO-ABWR-0035.A2 – *Hitachi-GE to provide a robust justification for the materials selected for the feedwater piping in UK ABWR, in line with the regulatory expectations for Action 1*.

The choice of feedwater piping material has an important impact on the operating chemistry applied to UK ABWR, because corrosion products released from some parts of the system are fed forward directly into the Reactor Pressure Vessel, and depending on the material selected, it may place requirements to make specific claims on the operating chemistry to mitigate materials degradation threats and/or other risks.

Hitachi-GE has presented a justification for the materials selected for the feedwater piping for UK ABWR [5]. ONR has assessed [5] and judged that the justification provided is not adequate. ONR raised questions about the scope and approach of the justification for the materials selected for the feedwater piping.

In responding to this ROA, Hitachi-GE will ensure the following:

- Demonstration that RGP, or other means that deliver at least an equally safe outcome, have been adopted.
- Due consideration to the classification of the pipework in its ALARP judgement;
- That the ALARP case is clear and provides sound arguments for all sections of the feedwater system;
- Review their use of Cost Benefit Analysis (CBA) and remove as a basis for the argument, or if appropriate to include, ensure that the scope of the CBA presented is complete;
- Demonstrate that other reasonably practicable options for material selection have been appropriately considered;
- Demonstrate that the expectations provided in SAP EKP.1 regarding inherent safety, have been appropriately considered.

The above considerations and resulting justifications were provided in the response to RQ-ABWR-1329. The Material Selection Report for Nuclear Boiler Systems will be re-submitted by 31st July 2017. The work that has been undertaken is expected to close out this ROA.

ACTION ROA-RO-ABWR-0035.A3 – *Hitachi-GE to provide suitable and sufficient evidence to support the claims made regarding material degradation risks and mitigations in the UK ABWR safety case.*

To support the SFAIRP assessments presented in the various Material Selection reports, Hitachi-GE will prepare four Topic Reports (TRs) on those significant material degradation mechanisms against which risks to UK ABWR are specifically assessed, i.e.;

- Flow-Accelerated Corrosion (FAC),
- Stress Corrosion Cracking (SCC),
- Irradiated Assisted Stress Corrosion Cracking (IASCC),
- Neutron Irradiation Embrittlement.

These mechanisms are considered specifically on the basis that they present the most significant risks to reactor coolant pressure boundary integrity and would require a future Licensee of the UK ABWR to develop appropriate arrangement to manage the associated risks to plant. Other degradation mechanisms such as thermal ageing, fatigue or general corrosion are recognised as posing potential risks to plant, however, they will be duly considered in relevant SFAIRP evaluations of Material Selection rather than in specific TRs.

To address the specific requirements of this RO action; within the TRs, Hitachi-GE will provide the following information in order to provide suitable and sufficient supporting evidence to the material selection SFAIRP assessments:

- Identification and justification of the plant conditions under which each of the degradation mechanisms are active and definition of assessment criteria to be used in the SFAIRP evaluations. This will be based on relevant international OPEX of BWR and ABWR plant and other relevant literature available.
- An overview of available countermeasures that can be used to mitigate against each material degradation mechanism and quantitative evidence to demonstrate effectiveness based on laboratory data, modelling and measurements and, where available, relevant international OPEX of BWR and ABWR plant. The relationships between this evidence and UK ABWR safety case claims will be clearly established and referenced appropriately with particular attention paid to structural integrity, control of reactor chemistry and radiation protection (including source term reduction).
- Summary and ranking of any residual material degradation risks to UK ABWR following SFAIRP evaluation of material selection. The ranking will consider the safety significance of degradation and likelihood of failure and be sufficient to enable a future Licensee to develop appropriate inspection programmes as part of a wider asset management strategy. Significant residual risks will be discussed specifically with respect to indicative rates of degradation to demonstrate that the risks can be managed safely throughout station life.

RO-ABWR-0035.A4 – *Hitachi-GE to provide a robust justification for the material(s) selected for the 'bottom drain line' in UK ABWR.*

ONR raised RO-ABWR-0034 on RPV Bottom Drain Line (BDL), requesting Hitachi-GE provide a demonstration that the inclusion of a BDL in the UK ABWR design achieves inherent safety and reduces risks SFAIRP.

Hitachi-GE provided the ALARP report of RPV BDL [11] which also included the justification for the material selection of BDL. In response, ONR raised a number of RQs and an additional Action on RO-ABWR-0035. Specific issues raised with respect to Material Selection include:

・Taking credit for the combination of operating chemistry and new materials selected for the line, to claim it results in lower doses to workers (relative to the reference plant);

・Inconsistent application of arguments relating to the risk of introducing un-intended consequences as a result

of design/materials changes;
・No consideration of the potential detriments of dissimilar metal welding in the 'bottom drain line' and the impact this may have on the evaluation of LOCA risk.

In order to provide further justification and satisfy ONR expectation, Hitachi-GE propose the following scope of work to address Action 4 as described in the following paragraphs:

ACTION ROA-RO-ABWR-0035.A4.1 Holistic ALARP evaluation of CUW system material selection
The material selection of BDL (Area 7) and other CUW Areas will be reconsidered based on benefits and detriments associated with the material selection for CUW system as a whole, for example; dissimilar metal welding, SCC potential and worker dose. Sensitivity analysis will be performed to support the conclusions of this holistic assessment.
Responses of related RQs (including RQ-ABWR-1111 and 1087) are taken into account in this reconsideration.

ACTION ROA-RO-ABWR-0035.A4.2 Justification of reactor chemistry and impact on worker dose
Hitachi-GE will consider the influence of reactor water chemistry and operating conditions in the BDL and dose rate associated with selected material(s) . Sufficient evidence including relevant OPEX will be provided to support any assumptions used in this assessment.

ACTION ROA-RO-ABWR-0035.A4.3 Consideration of un-intended consequences as a result of design/materials changes
Hitachi-GE will explain the risk of introducing un-intended consequences as a result of design/materials changes and demonstrate reliability of associated changes in manufacturing techniques that may be required as a consequence.

ACTION ROA-RO-ABWR-0035.A4.4 Consideration of the potential detriments of dissimilar metal welding
If the holistic assessment of material selection requires dissimilar metal welding (DMW) in the bottom drain line, Hitachi-GE will demonstrate that these can be fabricated with sufficient structural integrity for the design operating life. This will be supported by relevant manufacturing OPEX of DMW in BWRs and ABWRs.
By performing the proposed scope of work, Hitachi-GE intend to appropriately justify the material selection of BDL as ALARP. Justifications of these actions has been described in the Individual Material Selection Report for Systems by the end of December 2016.

The above considerations and resulting justifications were provided in the response to RQ-ABWR-1346.
The work that has been undertaken is expected to close out this ROA.

RO-ABWR-0035.A5 – *Hitachi-GE to provide a robust justification for the materials selected for the Feedwater Heater Drain and Vent System (HD/HV) System in UK ABWR.*

The choice of piping material selected for the HD/HV system has taken into account hazards and degradations to be minimised. Hitachi-GE recognise that the choice of operating chemistry itself may have an important impact on materials degradation risks in the HD/HV system and that corrosion products (most notably iron) present in this part of the HD/HV system may have important consequences for the control of feedwater iron concentrations and the resulting impact on operator dose and fuel integrity concerns.

In responding to this ROA, Hitachi-GE will:

- Ensure that the impact of assumptions made on the ability of the UK ABWR operating chemistry to mitigate FAC in the HD/HV system and to reduce worker dose as low as reasonably practicable have been adequately evaluated, with suitable and sufficient evidence;
- Demonstrate that Operational Experience (OPEX) and appropriate optioneering has been applied, including consideration of IAEA Safety Guide NS-G-1.13 "Radiation Protection Aspects of Design for Nuclear Power Plants";
- Give appropriate emphasis to the fact that Dissolved Oxygen (DO) cannot be directly controlled within the HD/HV system and may be reduced by HWC and OLNC;

- Ensure that the materials selected for the HD/HV system pipework meet the expectations of Relevant Good Practice (RGP), either by using the material that represents RGP, or providing an argument that the UK ABWR Design material is appropriate and change would be grossly disproportionate. This will demonstrate that the UK ABWR design reduced risks ALARP;
- Ensure that all relevant queries raised are considered and responded to.

To ensure that the arguments above are clearly outlined, Hitachi-GE will provide a concise ALARP assessment, that will augment the ALARP assessment already carried out within the Material Selection Report for Power Cycle Systems. The Material Selection Report for Power Cycle Systems will be updated to incorporate the revised ALARP assessment and re-submitted by 14th July 2017. Completion of this work to justify that the UK ABWR HD Material Selection reduces risks ALARP is expected to close out this ROA.

RO-ABWR-0035.A6 – *Hitachi-GE to provide a robust justification for the materials selected for the Residual Heat Removal System (RHR) main pipework in UK ABWR.*

Hitachi-GE recognise the main overall reasons for ONR's judgement that Hitachi-GE's justification is inadequate are:

- Hitachi-GE's conclusions regarding the impact and importance of the combination of key operational practices (primarily Low Temperature Shutdown Cooling Mode (LT-SHC)) and materials choice, on the generation and deposition of radioactivity via the RHR pipework;
- Hitachi-GE's conclusions regarding the relative importance of the RHR system being in service for a short period of time, versus the overall importance of the impact of radioactivity spikes on RHR pipework during a shutdown.

Given this ONR assessment, Hitachi-GE will provide further ALARP justification for the use of CS. In particular, Hitachi-GE will:

- Consider and respond to all relevant queries;
- Adequately consider the relevant factors regarding the time (both duration and timing in the operating cycle) the RHR system is in service;
- Discuss the impact of operating practices (LT-SHC and flushing) on dose and source term with suitable and sufficient evidence;
- Ensure that risks are eliminated or reduced SFAIRP in terms of deposition, source term and thermal fatigue;
- Discuss differences of operation mode in worldwide BWRs;
- Demonstrate that relevant good practice and appropriate optioneering has been applied;
- Demonstrate that adequate consideration has been given to the impact of material selection and surface treatment techniques available to mitigate radioactivity deposition in the RHR.

The above considerations and resulting justifications were provided in the response to RQ-ABWR-1330. The Material Selection Report for Core Cooling Systems will be re-submitted by 31st July 2017. The work that has been undertaken is expected to close out this ROA.

RO-ABWR-0035.A7 – *Hitachi-GE to provide a robust justification that the amount of high cobalt alloy usage in UK ABWR has been reduced SFAIRP*

Hitachi-GE will provide a detailed process to respond to ROA7, to justify that the use of high cobalt alloys in the UK ABWR GDA design has been reduced, or is capable of being reduced, SFAIRP. This response will identify:

- All components with the high cobalt alloys included in the UK ABWR design. This will provide confidence that all components have been considered in the assessment;
- A detailed process that can be used to determine whether the material selected for a valve/valve-type reduce risks ALARP or whether further risk reductions are reasonably practicable. This process will:
    - Define the key criteria for selecting appropriate materials;
    - Clarify the significance of each criteria (i.e. why it is important that each is applied);
    - Demonstrate a logical and evidence-based approach for selecting materials, based on appropriate

groupings of components;
    - Be tested for relevant and applicable components, to demonstrate that the process achieves the objectives, and so provides confidence that risks are reduced, or are capable of being reduced, ALARP.
- Following production and application of the process, Hitachi-GE will ensure that clear statements are made about which materials will be used for specific UK ABWR components and valve/valve types; including defining which valves/valve-types will not have materials finally confirmed until the detailed design phase.
- How much the use of high cobalt alloys has been reduced in the UK ABWR compared to the reference plant.
- Clear conclusions on the materials that reduce risks ALARP.

Hitachi-GE will demonstrate that for the UK ABWR GDA design risks associated with high cobalt alloys are reduced, or are capable of being reduced, ALARP. This will include a justification that any subsequent changes in component materials will not impact the overall design, i.e. that the UK ABWR GDA design does not foreclose options for the future licensee to further reduce the presence of high cobalt alloys in the design. The above considerations and resulting justifications will be provided in the response to RQ-ABWR-1458 by 30th June 2017. Where submissions are impacted as a result of RQ responses, these will be updated and re-submitted by 31st July 2017.

RO-ABWR-0035.A8 – *Hitachi-GE to provide a robust justification that the treatments applied to material surfaces in UK ABWR reduce radioactivity SFAIRP*

To clearly outline the case for surface treatment application presented at the GDA stage and justify why this is acceptable, Hitachi-GE will provide a detailed process in response to ROA8. This response will identify:

- Plant items that contribute significantly to release or deposition of corrosion products (and subsequent worker dose uptake), and direct activation and release of material where application of surface treatments has the potential to reduce risks;
- A detailed process that can be used to determine whether the reference design surface finish reduces risks ALARP or whether further surface treatment to reduce risk is reasonably practicable. This process will:
    - Define the key criteria for selecting appropriate surface treatments;
    - Identify any applicable OPEX and provide a demonstration this has been applied during the optioneering process;
    - Clarify the significance of each criteria (i.e. why it is important that each is applied);
    - Demonstrate a logical and evidence-based approach for selecting surface treatment techniques;
    - Specifically define the scope of work undertaken during GDA and remaining work to be completed during the site-specific phase.
- Clear conclusions on the surface treatments that reduce risks ALARP, as well as sensitivity analysis to determine whether future development work could provide an additional benefit.

The process will be tested for relevant and applicable systems and components, to demonstrate that the process achieves the objectives, and so provides confidence that risks are reduced, or are capable of being reduced, ALARP.

Hitachi-GE will communicate the systems/components that will be assessed to ONR, to ensure that the scope of work will be appropriate to meet the intent of the ROA.

Following production and application of the process for several key systems and components, Hitachi-GE will ensure that clear statements are made about which surface treatments will be used for specific UK ABWR systems and components; including defining which systems and components will not have surface treatments finally confirmed until the detailed design phase. Where the process identifies that further OPEX or laboratory data is required to justify the application of a surface treatment technique to one of the subject components it will be shortlisted for further consideration at the site-specific phase. It is noted that the surface treatment techniques discussed could be applied either in the factory during fabrication, or on-site during commissioning.

Hitachi-GE will demonstrate that for the UK ABWR GDA design risks associated with reduction of radioactivity by surface treatment are reduced, or are capable of being reduced, ALARP. This will include a justification that any subsequent changes in component/system surface treatments will not impact the overall design, i.e. that the UK

ABWR GDA design does not foreclose options for the future licensee to apply particular surface treatments where additional evidence of a prolonged benefit is available. The arguments outlined in the response to ROA8 will complement minimising radioactivity with the overall argument presented in the response to RO-ABWR-0072, that the UK ABWR chemistry control regime will ensure that radioactivity is minimised SFAIRP during commissioning operations.

The above considerations and resulting justifications will be provided in the response to RQ-ABWR-1455 on 7th July 2017. Where submissions are impacted as a result of RQ responses, these will be updated and re-submitted by 31st July 2017.

Summary of impact on GDA submissions:

GDA Submission Documents Document ID, Document Number	C/U	Related GDA RO Actions(s)	Submission Date to ONR
UK ABWR Operating Chemistry and Mitigation of Stress Corrosion Cracking (Response to RQ-ABWR-1324) GA91-9201-0003-02112, 1E-GD-5077, Rev.0	C	N/A	27-Apr.-2017
Assessment of Responses to RO-ABWR-0035: Initial Queries on Rev. 1 of the TR on FAC (Response to RQ-ABWR-1327) GA91-9201-0003-02116, 1E-GD-5080, Rev.0	C	N/A	27-Apr.-2017
Assessment of Responses to RO-ABWR-0035: Queries on the Approach and Outcome of the Materials Selection Justification for Feedwater Pipework (Response to RQ-ABWR-1329) GA91-9201-0003-02113, 1E-GD-5082, Rev.0	C	N/A	27-Apr.-2017
Assessment of Responses to RO-ABWR-0035: Queries on Revision 1 of the Materials Selection Report for Core Cooling Systems (Response to RQ-ABWR-1330) GA91-9201-0003-02118, 1E-GD-5083, Rev.0	C	N/A	11-May-2017
Assessment of Responses to RO-ABWR-0035: Queries on Revision 2 of the Materials Selection Report for Reactor Auxiliary Systems (Response to RQ-ABWR-1332) GA91-9201-0003-02110, 1E-GD-5085, Rev.0	C	N/A	27-Apr.-2017
Assessment of Responses to RO-ABWR-0035: Queries on Revision 2 of the Materials Selection Report for Power Cycle Systems (Response to RQ-ABWR-1334) GA91-9201-0003-02108, 1E-GD-5087, Rev.0	C	N/A	27-Apr.-2017
Stellite Reduction in UK ABWR (Response to RQ-ABWR-1339) GA91-9201-0003-02107, 1E-GD-5088, Rev.0	C	N/A	27-Apr.-2017

Material finishes to be applied to UK ABWR (Response to RQ-ABWR-1342) GA91-9201-0003-02106, WPE-GD-0367, Rev.0	C	N/A	11-May-2017
Materials Selection Justification for the Bottom Drain Line (Response to RQ-ABWR-1346) GA91-9201-0003-02022, SE-GD-0591, rev.0	C	N/A	27-Apr.-2017
Stellite sources in UK ABWR (Response to RQ-ABWR-1453) GA91-9201-0003-02200, 1E-GD-5093	C	N/A	29-Jun.-2017
Further queries on material finishes in UK ABWR (Response to RQ-ABWR-1455) GA91-9201-0003-02201, 1E-GD-5094	C	N/A	07-Jul.-2017
Further queries on Stellite reduction in UK ABWR (Response to RQ-ABWR-1458) GA91-9201-0003-02204, 1E-GD-5095	C	N/A	30-Jun.-2017
Queries on Rev. 1 of the Topic Report on SCC (Response to RQ-ABWR-1461) GA91-9201-0003-02203, 1E-GD-5096	C	N/A	29-Jun.-2017
Further Queries on Rev. 1 of the Topic Report on FAC (Response to RQ-ABWR-1465) GA91-9201-0003-02202, 1E-GD-5097	C	N/A	29-Jun.-2017
Material Selection Report for Power Cycle Systems, GA11-1001-0025-00001, 1D-GD-0024, Rev.3	U	N/A	14-Jul.-2017
It is noted that the suite of material selection documents will be updated to take account of the arguments in the RQ responses listed above, as well as RQ-ABWR-1325, RQ-ABWR-1326, RQ-ABWR-1328, RQ-ABWR-1331 and RQ-ABWR-1333.			

U: Update, C: Create

Programme Milestones/ Schedule:

See attached Gantt Chart (Table 1).

Reference:

[1] Hitachi-GE Ltd., Material Selection Report, GA11-1001-0002-00001, 1D-GD-0002, Rev.2, October 2015.
[2] International Atomic Energy Agency, International General Aging Lesson Learned (IGALL) report, http://www-ns.iaea.org/projects/igall/.
[3] United States Nuclear Regulatory Commission, NUREG-1801, Rev.2, General Aging Lesson Learned (GALL) report, 2010.
[4] e.g. EPRI Materials Degradation Matrix, Revision 3 (2013).
[5] Materials Selection Report for Nuclear Boiler Systems, 1D-GD-0018, Revision 2, Hitachi-GE, 2017.
[6] Office for Nuclear Regulation, RQ-ABWR-1329: Assessment of Responses to RO-ABWR-0035: Queries on the Approach and Outcome of the Materials Selection Justification for Feedwater Pipework, February 2017.
[7] Hitachi-GE, Topic Report on Material Degradations - FAC and Erosion-Corrosion, GA91-9201-0001-00212, 1E-GD-5048, Rev.0, May 2016.
[8] Hitachi-GE, Topic Report on Material Degradations – Stress Corrosion Cracking, GA91-9201-0001-00225, 1E-GD-5051, Rev.0, June 2016.
[9] RO-ABWR-0034, Demonstrating the Inclusion of a 'Bottom Drain Line' in the UK ABWR Achieves Inherent Safety and Reduces Risks SFAIRP, ONR, December 2014. TRIM 2014/118089.
[10] UK ABWR GDA, ALARP Consideration on RPV Bottom Drain Line, SE-GD-0241, Rev. 2, Hitachi-GE, August 2016.

[11] Hitachi-GE Ltd., Materials Selection Report for Power Cycle Systems, GA11-1001-0025-00001, 1D-GD-0024, Revision 2, 2017.
[12] Office for Nuclear Regulation, RQ-ABWR-1324: UK ABWR Operating Chemistry and Mitigation of Stress Corrosion Cracking, February 2017.
[13] Hitachi-GE Ltd., Materials Selection Report for Core Cooling Systems, GA11-1001-0029-00001, 1D-GD-0020, Revision 1, February 2017.
[14] Office for Nuclear Regulation, RQ-ABWR-1330: Assessment of Responses to RO-ABWR-0035: Queries on Revision 1 of the Materials Selection Report for Core Cooling Systems, February 2017.
[15] Office for Nuclear Regulation, RO-ABWR-0006: Source Terms, July 2015.
[16] Hitachi-GE Ltd., Topic Report on Source Term Reduction by Material Selection, GA91-9201-0001-00202, 1E-GD-5046, Rev. 1, December 2016.

Table 1 RO-ABWR-0035 Gantt Chart

Resolution Plan for RO-ABWR-0035	≪Legend≫ ■ … Plan ⟷ … Actual		2014		2015												2016												2017											
			11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Level	Action Title	Start(Plan)	Finish(Plan)																																				
1	Regulator's issue of RO	14-Nov-14	13-Mar-15																																				
1.1	ONR Issue RO	14-Nov-14	16-Dec-14																																				
1.2	Hitachi-GE Acknowledge RO & Issue Resolution Plan	17-Dec-14	06-Feb-15																																				
1.3	Regulator's confirm credibility of Resolution Plan	09-Feb-15	20-Feb-15																																				
1.4	Regulator's publish RO and Resolution Plan	23-Feb-15	13-Mar-15																																				
2	Regulator's issue of RO Rev.1	30-Jun-15	09-Oct-15																																				
2.1	ONR Issue RO Rev.1	30-Jun-15	28-Jul-15																																				
2.2	Hitachi-GE Acknowledge RO Rev.1 & Issue Resolution Plan	29-Jul-15	02-Sep-15																																				
2.3	Regulator's confirm credibility of Resolution Plan for RO Rev.1	03-Sep-15	18-Sep-15																																				
2.4	Regulator's publish RO Rev.1 and Resolution Plan	21-Sep-15	09-Oct-15																																				
3	Regulator's issue of RO Rev.2	15-Aug-16	09-Oct-16																																				
3.1	ONR Issue RO Rev.2	15-Aug-16	16-Sep-16																																				
3.2	Hitachi-GE Acknowledge RO Rev.2 & Issue Resolution Plan	19-Sep-16	30-Sep-16																																				
3.3	Regulator's confirm credibility of Resolution Plan for RO Rev.2	03-Oct-16	14-Oct-16																																				
3.4	Regulator's publish RO Rev.2 and Resolution Plan	17-Oct-16	28-Oct-16																																				
4	Regulator's issue of RO Rev.3	03-Oct-16	16-Dec-16																																				
4.1	ONR Issue RO Rev.3	03-Oct-16	04-Nov-16																																				
4.2	Hitachi-GE Acknowledge RO Rev.4 & Issue Resolution Plan	04-Nov-16	02-Dec-16																																				
4.3	Regulator's confirm credibility of Resolution Plan for RO Rev.3	02-Dec-16	09-Dec-16																																				
4.4	Regulator's publish RO Rev.3 and Resolution Plan	09-Dec-16	16-Dec-16																																				
5	Regulator's issue of RO Rev.4	20-Mar-17	14-Jul-17																																				
5.1	ONR Issue RO Rev.4	20-Mar-17	14-Apr-17																																				
5.2	Hitachi-GE Acknowledge RO Rev.4 & Issue Resolution Plan	14-Apr-17	30-Jun-17																																				
5.3	Regulator's confirm credibility of Resolution Plan for RO Rev.4	01-Jul-17	07-Jul-17																																				
5.4	Regulator's publish RO Rev.4 and Resolution Plan	08-Jul-17	14-Jul-17																																				

Table 1 RO-ABWR-0035 Gantt Chart (cont'd)

Resolution Plan for RO-ABWR-0035		≪Legend≫	
		■ ··· Plan ⟷ ··· Actual	
Level	Action Title	Start(Plan)	Finish(Plan)
6	Preparation of Submissions and Closure of RO Action 1&2	17-Nov-14	31-Jul-17
6.1	Submissions	17-Nov-14	28-Feb-17
6.2	Response to RQs	06-Mar-17	30-Apr-17
6.3	Closure of RO Action	01-Apr-15	31-Jul-17
7	Preparation of Submissions and Closure of RO Action 3	16-Aug-16	30-Sep-17
7.1	Submissions	01-Sep-16	28-Feb-17
7.2	Response to RQs	06-Mar-17	30-Jun-17
7.3	Closure of RO Action	01-Sep-16	30-Sep-17
8	Preparation of Submissions and Closure of RO Action 4	03-Oct-16	31-Jul-17
8.1	Response to RQs	10-Oct-16	30-Apr-17
8.3	Closure of RO Action	03-Oct-16	31-Jul-17
9	Preparation of Submissions and Closure of RO Action 5-8	20-Mar-17	30-Sep-17
9.1	Response to RQs	06-Mar-17	14-Jul-17
9.2	Closure of RO Action	20-Mar-17	30-Sep-17
10	Regulator's Closure of RO	01-Apr-15	30-Sep-17
10.1	Regulator's assessment	01-Apr-15	22-Sep-17
10.2	Regulator's publication of RO closure letter	23-Sep-17	30-Sep-17