Hitachi-GE Nuclear Energy, Ltd.
UK ABWR GENERIC DESIGN ASSESSMENT
Resolution Plan for RO-ABWR-0072
Suitable and sufficient consideration of chemistry control during UK ABWR commissioning

RO TITLE:	Suitable and sufficient consideration of chemistry control during UK ABWR commissioning	
REVISION :	1	
Overall RO Closure Date (Planned):		9th March 2017
REFERENCE DOCUMENTATION RELATED TO REGULATORY OBSERVATION		
Regulatory Queries	-	
Linked ROs/RIs	RO-ABWR-0006	
Other Documentation	GA91-9201-0001-00163, GA91-9201-0001-00207, GA91-9201-0001-00209	

Scope of work :

Background

Hitachi-GE investigate the operating experiences during commissioning phase not only in Japan but also in USA where most BWRs use the water chemistry regime of Hydrogen Water Chemistry (HWC) with Noble Metal Chemical Addition (NMCA) and Depleted Zinc Oxide (DZO) injection in order to evaluate the options which reduce risks As Low As Reasonably Practicable (ALARP). However, there are no Boiling Water Reactor (BWR) plants which applied the same water chemistry regime from the beginning as UK ABWR will apply so far. Therefore the discussion on when and how HWC, NMCA and DZO are applied during commissioning phase became main part in the optioneering workshop to minimise the risks ALARP. Based on the workshop results, water chemistry control during commissioning phase are described in the GDA documents [1 – 3] which ONR assessed.
As a result of assessment, ONR concluded that a developed methodology to produce ALARP justifications for chemistry control during commissioning phase of reactor operations was adequate, however commented on Hitachi-GE's current approach as follows.

- *The aims and objectives for chemistry control during UK ABWR commissioning are not clearly stated.*
- *As presented, the ALARP demonstration appears to focus very heavily on the need to mitigate Stress Corrosion Cracking (SCC) and risks to the structural integrity of the plant, as opposed to minimising long-term Operational Radiation Exposure.*
- *It is not clear which parts of the plant are, and need to be targeted, to claim risks will be reduced to ALARP by the choice of chemistry control during commissioning.*
- *Little evidence is presented to support some of the key arguments invoked to dismiss the application of alternative options.*

Although minimisation of radiation exposure was considered to be included adequately in the ALARP assessment for the commissioning phase, Hitachi-GE recognised that the explanation and evidence on identifying and dismissing options were not sufficient.

Scope of Work

Hitachi-GE understands that this Regulatory Observation (RO) is associated with the options of chemistry control during commissioning phase to reduce radioactivity ALARP. For this RO, commissioning period is defined from first operations until the time at which the normal at-power operating chemistry of HWC/OLNC and DZO has been established and start-up and shutdown procedures follow the expected practices for the plant. Hitachi-GE considers

first operations as those of cold functional testing without fuel.

The response to this RO will demonstrate that the commissioning chemistry for UK ABWR has reduced radioactivity ALARP.

In the response to this RO Hitachi-GE will provide the following suitable and sufficient information to ensure that a future Licensee/operator may choose to adopt to achieve adequate chemistry control during UK ABWR commissioning to claim risks will be reduced to ALARP:

- The main, most recent, relevant good practices and approaches in chemistry implemented for commissioning Boiling Water Reactor (BWR) plants similar to, or the same as UK ABWR;
- The specific aims and objectives for chemistry control during UK ABWR commissioning;
- The main fundamental chemistry processes and/or steps expected to be involved in UK ABWR commissioning, with specific emphasis on meeting the objectives identified above, rather than what may be achieved with the current design or arrangements;
- Any constraints on other matters relating to commissioning activities, which may influence the chemistry choices;
- Demonstration of the availability and capability of UK ABWR systems to support the above, main fundamental UK ABWR expected chemistry processes/procedures;
- Any potential alternative methods to implement chemistry control during commissioning operations;
- Any necessary, reasonably practicable improvements to UK ABWR systems to deliver complementary chemistry procedures;
- Chemistry parameters/procedures/approaches which are suitable for a prospective UK ABWR operator to give further consideration to;
- Areas where further development work/evidence/plant experience is required to underpin future decisions on chemistry control during UK ABWR commissioning.

Hitachi-GE is aware that the number of applicable options during commissioning phase, whose main purpose is to reduce dose rate, is limited for UK ABWR, based on the previous BWR and ABWR plant experiences. However, some activities conducted to maintain the integrity of SSC during commissioning phase are related to the radioactivity reduction in the future operation. For example, it is a good practice to reduce the number of valve operations and maintain low crud concentration in the water not only for the integrity of valve seat made of Stellite and to prevent the seat leakage during the operation, but also to reduce the Co release which will be activated in the later power operation. Therefore Hitachi-GE will collect such kind of information among the commissioning activities related to radioactivity reduction in the future operation from the wider view point. Hitachi-GE are also aware that passivation of surfaces during commissioning is an important factor in minimising dose rates during normal operation. Information on this aspect will also be collected.

After gathering the information, effective practices and options during commissioning, their objectives and targets, their fundamental processes and any constraints will be identified in order to reduce radioactivity and dose rate in the future operation. Any potential alternative methods to implement chemistry control, any necessary, reasonably practicable improvements to UK ABWR systems, chemistry parameters/procedures/approaches and areas where further development work/evidence/plant experience is required will be also identified.

Based on the information obtained above, Hitachi-GE will demonstrate the expected approach to chemistry control during UK ABWR commissioning is capable of reducing radioactivity ALARP by using the same methodology described in the GDA document [2].

This Resolution Plan describes Hitachi-GE's current plan to address the RO however as the work develops there may be a need to select alternative means to address the RO, through agreement with the regulators.

Description of work:

ACTION RO-ABWR-0072.1 – *Hitachi-GE are required to provide an evaluation of current, relevant good practice, in the field of BWR commissioning.*

Hitachi-GE will gather the additional information to identify and describe Relevant Good Practice (RGP) in the field of BWR and ABWR commissioning which was not included in the previous report [3]. Any good practices identified in engineering, operations and/or management of safety will be considered. Potential options to satisfy the objectives of commissioning chemistry control beyond the previous engineering restriction will be also considered. This may include options that have not yet been carried out on a BWR, but are considered to be beneficial. The response will include not only chemistry control but also general commissioning activities including passivation of surfaces before power raise.

UK ABWR will apply the operating chemistry of Hydrogen Water Chemistry (HWC), Depleted Zinc Oxide (DZO) and On-Line Noble Metal Chemical Addition (OLNC) from the start of plant life. When OLNC is applied during at power, oxide film is generally restructured and new stable oxide film is formed. This means that water chemistry regime at power will affect the effectiveness of oxide film formed under the previous conditions of water chemistry on reducing cobalt-60 deposition reduction. Therefore each gathered chemistry control option or good practice from the previous commissioning experiences will be judged its applicability to UK ABWR clearly whether each option or activity remains relevant based on the at power chemistry regime.

In response to Action 1, Hitachi-GE will provide a topic report on commissioning chemistry Revision 1 by 30 Nov. 2016.

ACTION RO-ABWR-0072.2 – *Hitachi-GE are required to provide a description of the specific aims and objectives for chemistry control during UK ABWR commissioning.*

Hitachi-GE understand that the specific aims and objectives for chemistry control during commissioning are fundamentally to maintain the structural material integrity, to reduce the risk of fuel failure after fuel loading and to reduce the radioactivity generation and accumulation in the primary system during future operation from the viewpoint of nuclear safety and dose minimisation in the long term. In the previous ALARP assessment the large part of description was on the material integrity. Therefore the emphasis on dose rate reduction rather than material degradation will be given in the response to become the same level of detail. Regarding to the gathered RGP or potential options in the Action 1, Hitachi-GE will clearly describe what the principal aims and objectives for chemistry control during UK ABWR commissioning are against the focused SSCs and phenomena most significant to nuclear safety such as reactor internals and so on. Hitachi-GE will also prepare the clear description of following items:

- UK ABWR SSCs which chemistry control during commissioning is specifically targeting, the reason(s) why;
- The main fundamental chemistry processes/steps expected to be performed during UK ABWR commissioning; Chemistry parameters/procedures/approaches which are suitable for a prospective UK ABWR operator to give further consideration to, and provide an adequate justification for why this is appropriate;
- <u>The effect of chemistry controls such as pH and zinc concentration during commissioning phase on the oxide film structure in order to reduce future Co incorporation into the oxide film.</u>

<u>The detailed scientific basis on the relationship between reactor water chemistry, oxide film structure and Co deposition rate will be discussed in the topic report on radioactivity behaviour in UK ABWR, which will be prepared as a response to RO-ABWR-0006 Action 9 by the end of December 2016. This topic report will be referred and the effect of water chemistry options on dose rate reduction will be described in the topic report prepared for this action.</u>

In response to Action 2, Hitachi-GE will provide a topic report on commissioning chemistry Revision 1 by 30 Nov. 2016.

ACTION RO-ABWR-0072.3 – *Hitachi-GE are required to provide a robust demonstration to justify the expected UK ABWR commissioning procedure(s) is capable of reducing risks SFAIRP, based on the responses to Actions 1 and 2.*

Hitachi-GE will produce an ALARP justification for the expected UK ABWR commissioning procedure(s) is capable of reducing risks SFAIRP based on the responses to Action 1 and 2. To achieve this the ALARP justification will:

- Consider the capability and availability of UK ABWR systems to deliver chemistry control;
- Consider not only clear benefits and detriments but also those where the information is absent;
- Consider alternative methods (options) to implement chemistry control including the extension of hot functional testing period without fuel, chemical additions and so on;
- Consider the effect of water chemistry control during commissioning phase on the cobalt accumulation on structural materials in the future operation;
- Consider the historical development of each option;
- Consider any reasonably practicable improvements/modifications to the capability and availability of UK ABWR systems to deliver chemistry control;
- Present suitable and sufficient evidence to support the arguments presented, especially where claims of gross disproportion are invoked;
- Identify where further development work/evidence/plant experience is required to underpin future decision(s).

In response to Action 3, Hitachi-GE will provide topic reports on the Water Chemistry Regime ALARP Assessments on the Iron Control at Power, Commissioning, Start-Up and Shutdown operational modes Revision 1 by 9 Dec. 2016.

Summary of impact on GDA submissions:

The outcome of the ALARP justification may impact the GDA documents of reference [1] and [2] when new information is obtained. During the development of PCSR Rev C the optimised solution will be incorporated into reactor chemistry and/or commissioning topics.

Programme Milestones/ Schedule:

See attached Gantt Chart (Table 1)

Reference:

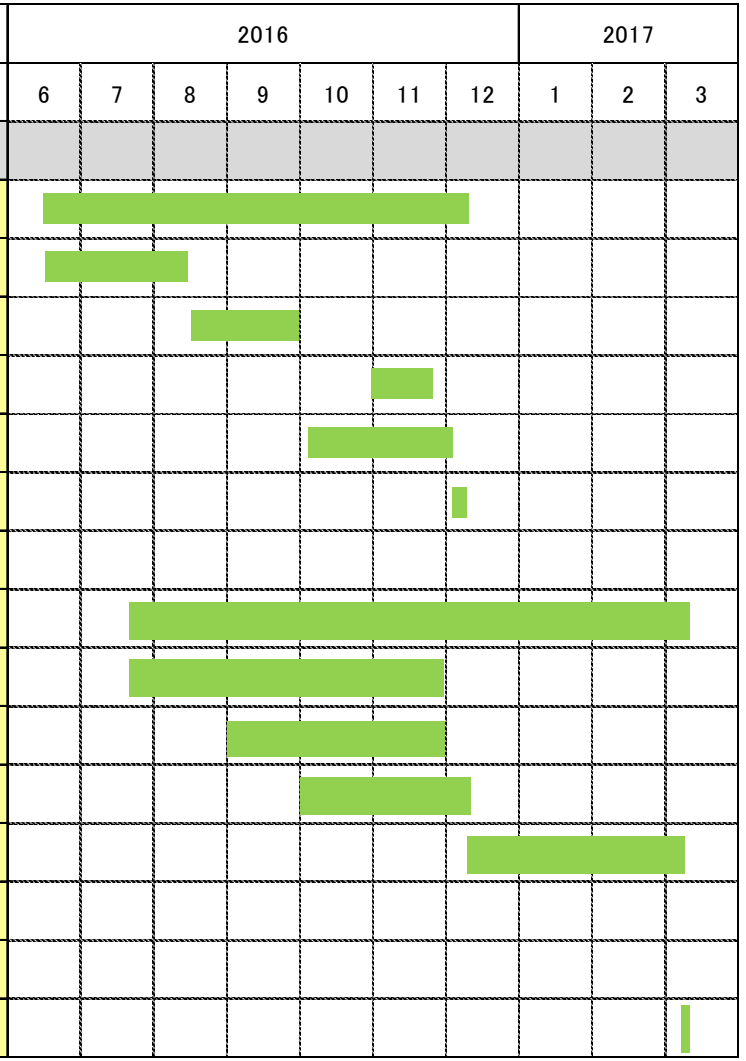
[1] Topic Report on the Water Chemistry Regime ALARP Assessments on the Iron Control at Power, Commissioning, Start-Up and Shutdown operational modes: Part 1 – Main Justification, GA91-9201-0001-00163, WPE-GD-0206, Revision 0, 28 April 2016

[2] Topic Report on the Water Chemistry Regime ALARP Assessments on the Iron Control at Power, Commissioning, Start-Up and Shutdown operational modes: Part 2 -ALARP Workshop Method and Record, GA91-9201-0001-00207, WPE-GD-0272, Revision 0, 28 April 2016

[3] Topic Report on Commissioning Chemistry, GA91-9201-0001-00209, WPE-GD-0276, Revision 0, 28 April 2016

Table 1 RO-ABWR-0072 Gantt Chart

Resolution Plan for RO-ABWR-0072		≪Legend≫	
		■ ･･･ Plan ←→ ･･･ Actual	
Level	Action Title	Start(Plan)	Finish(Plan)
1	Regulator's issue of RO	13-Jun-16	09-Dec-16
1.1	ONR Issue RO	13-Jun-16	15-Aug-16
1.2	Hitachi-GE Acknowledge RO & Issue Resolution Plan	18-Aug-16	30-Sep-16
1.3	Hitachi-GE Issue Resolution Plan Rev.1	01-Nov-16	25-Nov-16
1.4	Regulator's confirm credibility of Resolution Plan	28-Nov-16	02-Dec-16
1.5	Regulator's publish RO and Resolution Plan	05-Dec-16	09-Dec-16
2	Preparation of Submissions and Closure of RO Action	18-Jul-16	09-Mar-17
2.1	RO Action 1	18-Jul-16	30-Nov-16
2.2	RO Action 2	01-Sep-16	30-Nov-16
2.3	RO Action 3	03-Oct-16	09-Dec-16
2.4	Regulator's assesment of submission	09-Dec-16	09-Mar-17
3	Regulator's Closure of RO		
3.1	Regulator's publication of RO closure letter	09-Mar-17	09-Mar-17



(Doc.ID# GA91-9201-0004-00074 Rev. 1)

Glossary

Glossary follows definition of this RO.

BAT – Best Available Techniques

BWR –Boiling Water Reactor

CRUD – Chalk River Unidentified Deposit

Expected event – events that are expected to occur over the lifetime of the plant. This does not include events that are inconsistent with the use of BAT such as accidents, inadequate maintenance and inadequate operation.

GEP – Generic Environmental Permit

Operational States – Including "normal operations" and "anticipated operational occurrences". For a nuclear power plant, this includes start-up, power operation, shutting down, shutdown, maintenance, testing and refuelling.

ORE – Operational Radiation Exposure

PCSR – Pre-construction Safety Report

RO – Regulatory Observation

ROA – Regulatory Observation Action

RPV – Reactor Pressure Vessel

Severe accident - As defined in the SAPs. A fault sequence which leads either to consequences exceeding the highest radiological doses given in the BSLs of Target 4, or to a substantial unintended relocation of radioactive material within the facility which places a demand on the integrity of the remaining physical barriers

SFAIRP – So Far as is Reasonably Practicable

Source term – The types, quantities, and physical and chemical forms of the radionuclides present in a nuclear facility that have the potential to give rise to exposure to radiation, radioactive waste or discharges

SSCs – Systems, Structures and Components

UK ABWR – UK Advanced Boiling Water Reactor