Hitachi-GE Nuclear Energy, Ltd.
UK ABWR GENERIC DESIGN ASSESSMENT
Resolution Plan for RO-ABWR-0043
(Demonstration of the adequacy of pH control in the Suppression Pool during accident conditions)

RO TITLE:	Demonstration of the adequacy of pH control in the Suppression Pool during accident conditions	
REVISION :	2	
Overall RO Closure Date (Planned):		28 Feb. 2017
REFERENCE DOCUMENTATION RELATED TO REGULATORY OBSERVATION		
Regulatory Queries	RQ-ABWR-0332 RQ-ABWR-0409 RQ-ABWR-0416	
Linked ROs	RO-ABWR-0066	
Other Documentation	GA91-9201-0001-00023, UE-GD-0219 – UK ABWR GDA – Topic report on Design Basis Analysis, Revision 3, 27 November 2014. GA91-9201-0001-00024, AE-GD-0102 – UK ABWR GDA – Topic report on Severe Accident Phenomena and Severe Accident Analysis, Revision D, 23 December 2014. GA91-9101-0003-00451, WPE-GD-0097 – UK ABWR GDA – Suppression Pool pH Model during Severe Accident, Revision 0, 23 December 2014.	

Scope of work :

Back ground

This Resolution Plan has been produced in response to Regulatory Observation RO-ABWR-0043 on Demonstration of the Adequacy of pH Control in the Suppression Pool during Accident Conditions sent in 16th March 2015. In the Pre-construction Safety Report (PCSR) [1] a safety claim is made upon the suppression pool in the event of a Severe Accident based upon the pH of the suppression pool water being maintained above a specific value. The PCSR claims that chemistry control within the suppression pool minimises radioactive releases So Far As Is Reasonably Practicable (SFAIRP), with the details provided in the relevant topic report [2]. The pH of the water within the suppression pool will be affected by the species released into it during an accident and there is no means to actively maintain the pH in the extant design. Regulatory Observation RO-ABWR-0043 requests Hitachi-GE needs to clarify the safety significance, likelihood and potential consequences for pH changes in the suppression pool. Also, Hitachi-GE is requested by this RO to explain how the UK ABWR design reduces the risks associated with this phenomenon SFAIRP.

A subsequent and closely related Regulatory Observation (RO-ABWR-0066) was issued by the Office for Nuclear Regulation in January 2016. The scope of RO-ABWR-0066 encompasses all aspects of chemistry considered in fault studies and requests Hitachi-GE to provide a demonstration that these have been given sufficient and suitable consideration within the safety case for the UK-ABWR. There is evidently a large overlap between the scopes of the two ROs. Therefore, to ensure that the overall response to the two ROs is comprehensive, consistent and coherent a number of aspects of the work originally contained within Revision 0 of this resolution plan will now be completed as part of delivering the resolution plan for RO-ABWR-0066. Details of how the analysis relating to the role of the suppression pool in mitigating release of radiologically significant nuclides has been split between the two resolution plans is presented in subsequent sections.

Scope of work
The response to this RO is to clarify the effect of suppression pool pH on the safety case for UK ABWR in GDA. This Resolution Plan shows actions and milestones for submissions intended to demonstrate the adequacy of pH control in the suppression pool during accident conditions. The detailed programme of work is shown below.

As a result of RO-ABWR-0066 the scope of work contained within this RO has been amended to ensure that the overall response to the two ROs is comprehensive, consistent and coherent. Essentially, those aspects relating to the technical analyses necessary to define the chemistry within the suppression pool under accident conditions are retained within this resolution plan. Aspects relating to how the suppression pool chemistry is considered in the context of the overall safety case for the UK ABWR will now be undertaken as part of the integrated package of work to deliver the resolution plan for RO-ABWR-0066. With respect to the suppression pool, this package will comprise full definition of the claims, arguments and evidence associated with suppression pool chemistry, assessment of the sensitivity of radiological consequences to uncertainties in the understanding of the chemistry and the safety significance of the suppression pool chemistry relative to other aspects of chemistry that directly influence radiological consequences.

Division of the different aspects of the analysis between the two resolution plans does not change the overall scope of work required to respond to RO-ABWR-0043. The original scope of work presented in Revision 0 of this resolution plan will still be undertaken, only with some aspects integrated into the Topic Reports produced in response to RO-ABWR-0066.

Description of work:

RO-ABWR-0043.A1
Hitachi-GE are required to provide a description of the safety case claims and arguments for suppression pool pH control under accident conditions

Response to Action A1.

Hitachi-GE will update the relevant chapters of the PCSR for UK ABWR to Revision B to present fully the Claims and associated Arguments for iodine chemistry under both design basis and severe accident conditions. This will include Claims and Arguments specific to the pH control of the suppression pool and definition of which accidents make claims on the fission product scrubbing behaviour of the suppression pool. In developing the claims and Arguments, Hitachi-GE will take account of the controls adopted by other BWRs and, where relevant, other reactor designs, to reduce iodine release during accident scenarios.

The Claims and Arguments developed during Step 3 will be developed further and finalised during step 4 of the GDA process. These will be presented, along with a detailed summary of the types of supporting evidence that will be provided in the safety case, in the Strategy Report produced as part of the resolution plan for RO-ABWR-0066.

Also the updated PCSR chapters will describe the type of evidence that will be presented in support of the iodine chemistry (including suppression pool pH control) claims and arguments at Step 4 of the GDA.

In support of the revision of update of the PSCR at Step 3, Hitachi-GE will provide the impact of the suppression pool in each of the accident scenarios considered in a new Topic Report, “Topic Report on Demonstration of the Adequacy of pH Control in the Suppression Pool during Accident Conditions (RO-0043)”. This will delivered by 10 July 2015. This will include a preliminary assessment of the impact of the suppression pool on the consequence of L3 PSA for each of the relevant accident scenarios. In this calculation, 15 severe accidents (SAs) and LOCA-design basis accident (DBA) will be considered as accident scenarios for suppression pool claims.
The impact assessments developed during Step 3 will be developed further and finalised during step 4 of the GDA process. These will be presented in the Study Report produced as part of the resolution plan for RO-ABWR-0066.

RO-ABWR-0043.A2
Hitachi-GE are required to provide an evaluation of the pH change likely within the suppression pool for the various scenarios defined under Action 1

Response to Action A2.

Within Step 3 Hitachi-GE will provide calculations of pH changes against time for all relevant scenarios for both LOCA-DBA and SAs. In presenting the calculations Hitachi-GE will also;

- Clarify all assumptions made on chemistry, including basis for omissions/simplifications
- Clearly state the origin of the methods used
- Provide a detailed description of methods
- State source references for input data
- Evaluate both mitigated (active pH control) and unmitigated accident scenarios (no pH control)
- Adopt a level of conservatism appropriate to the analysis being undertaken (sufficiently conservative for Design Basis Accidents and best estimate for Severe Accidents)
- Clearly define applicability to UK ABWR

This analysis will be presented in the updated Topic Report "Suppression Pool pH Model during Design Basis Accident and Severe Accident Rev.1" to be submitted as part of Step 3. This will delivered by 10 July 2015. The response to RQ-ABWR-0416 will also be reflected in this Topic Report. Also, Topic Report "Suppression Pool pH Model during Design Basis Accident and Severe Accident, Revision 2" will be submitted as part of Step 4 to show detailed calculations of iodine releases with and without pH control in the suppression pool for DBA and SA scenarios. Calculations will be performed using a mechanistic model used for previous assessment but that will be enhanced to allow iodine-paint interactions and organic iodine production to be evaluated. The calculation method used for Sizewell B is also employed for some accident cases to allow comparison with the method used in the previous Topic Report. The response to this action is unchanged by issue of RO-ABWR-0066 and remains fully within the scope of this resolution plan.

RO-ABWR-0043.A3
Hitachi-GE are required to provide an evaluation of the radiological consequences of the pH change within the suppression pool under Action 2.

Response to Action A3.

In support of the revision of update of the PSCR at Step 3 Hitachi-GE will include in the updated Topic Report an assessment of the impact of the suppression pool and its chemistry on the iodine partitioning and release behaviour for each of the relevant accident scenarios (see response to Action RO-ABWR-0043-A1). In Step 3 Hitachi-GE will conduct iodine release calculations based on the results of pH calculation for relevant accident scenarios. Hitachi-GE will employ partitioning coefficient between I_2 (gas) and I_2 (liquid) to see the effect of pH on Iodine revaporization based on NUREG-CR-5732[3].

This will also delivered by 10 July 2015 as an update of topic report "Suppression Pool pH Model during Design Basis Accident and Severe Accident Rev1" together with pH change calculation in time for Step 3.

The information presented in the updated Topic Report at Step 3 will then be developed further at Step 4 and integrated into a comprehensive study of the impact of accident chemistry on radiological consequences. This study will include an assessment of the impact of suppression pool chemistry on iodine release. This study will be conducted

as part of the resolution plan for RO-ABWR-0066 and issued in the Topic Report "A Study of Chemistry Effects in UK ABWR Fault Studies", it will also consider the sensitivity of the radiological consequences to uncertainties in the data and understanding relating to suppression pool chemistry. To ensure that release from containment of nuclides of radiological significance, including iodine, is minimised ALARP, the study will include an assessment of the safety significance of suppression pool pH control in the context of all measures required to reduce release of iodine from containment for all of the accident scenarios considered.

RO-ABWR-0043.A4

Hitachi-GE are required to provide a justification that the pH control arrangements for the suppression pool in the UK ABWR reduces risks So Far As Is Reasonably Practicable, based upon the responses to Actions 1 to 3.

Response to Action A4.

This action will be conducted as part of the resolution plan for RO-ABWR-0066. Based on the analysis detailed in the responses to action 2 coupled with the results of actions 1 and 3 conducted as part of RO-ABWR-0066, Hitachi-GE will provide a justification for all measures required to reduce release of iodine from containment SFAIRP in the resolution plan for RO-ABWR-0066. In this action, Hitachi-GE will consider the following concepts in demonstration of ALARP;

- Demonstration that risks are broadly acceptable (i.e. below the SAP Target BSOs)
- Ensuring that no single accident dominates the overall risk
- Demonstration of adequate margin against the BSO taking into account the uncertainties in the analysis
- Safety measures to minimise radiological release should be effective across the broadest range of accident scenarios
- Defence in depth

The final revision of the PCSR, Rev. C, will be delivered for Step 4 assessment and will be based on the Topic Report " A Study of Chemistry Effects in UK ABWR Fault Studies" to be delivered by 4 November 2016 in Step 4 of GDA. This will be the principal supporting document summarising accident iodine chemistry. In the Study Report, an outline of pH control and other iodine-related system design requirements for the UK-ABWR will be proposed should analysis indicate that design changes are required to minimise iodine release SFAIRP.

Summary of impact on GDA submissions:

The technical analyses conducted as part of this resolution plan will initially be submitted as a new Topic Report during Step 3 of the GDA. As the GDA progresses into Step 4, the information contained in the Topic Report will be incorporated into the existing documents listed in WPE-GD-0150 that comprise the Reactor Chemistry Safety Case.

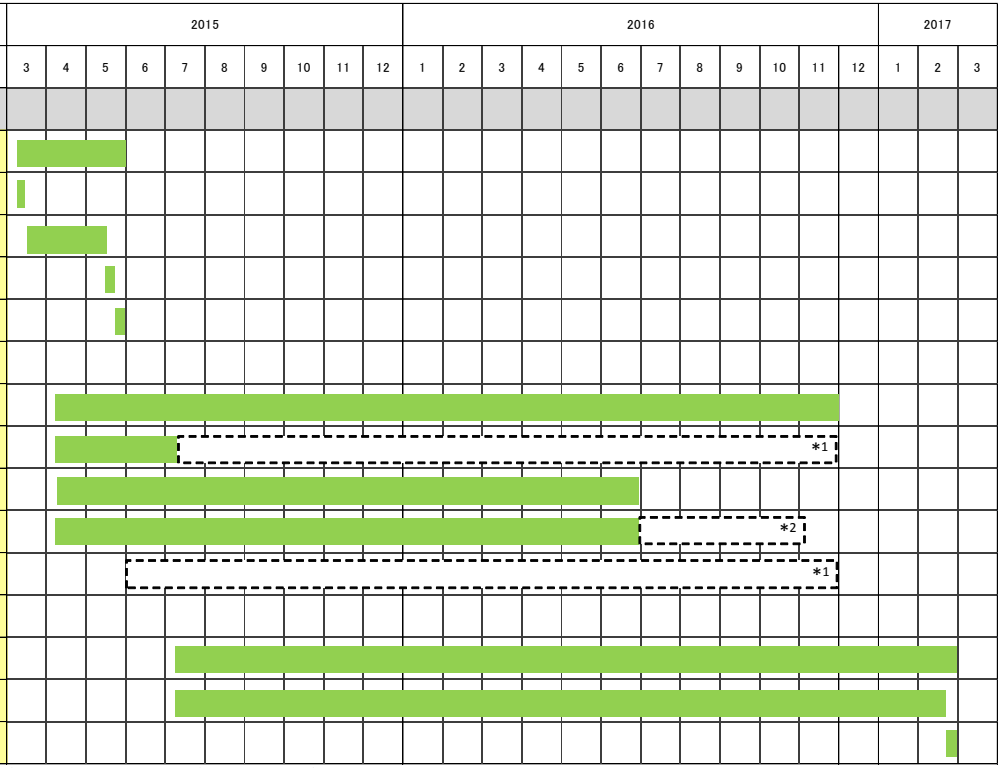
Action	STEP 3			STEP 4		
	GDA Submission Document	Contents	Submission Date to ONR	GDA Submission Document	Contents	Submission Date to ONR
A1	Topic Report "Demonstration of Adequacy of pH Control in the Suppression Pool during Accident Conditions (RO-0043)" (WPE-GD-0145)	-Claim and arguments for suppression pool pH -Level 3 PSA calculation for several SA and DBA as sensitivity analysis of pH control	10 July 2015	A Strategy for Consideration of Chemistry Effects in UK ABWR Fault Studies rev.0 (RO-0066) (TBD)	-Claim and arguments for suppression pool pH	31 May 2016
A2,A3	Topic Report " Suppression Pool pH Model during Design Basis Accident and Severe Accident, Revision 1" (WPE-GD-0097)	-Calculation of pH change in suppression pool for Several SA and DBA scenarios. -Simplified calculation of iodine release amount with and without pH control in suppression pool for some DBA and SA scenarios.	10 July 2015	Topic Report " Suppression Pool pH Model during Design Basis Accident and Severe Accident, Revision 2" (WPE-GD-0097)	-Detail calculation of iodine release amount with and without pH control in suppression pool for DBA and SA scenarios. -Investigation of pH control in other BWRs	30 June 2016
				A Study of Chemistry Effects in UK ABWR Fault Studies (RO-0066) (TBD)	-Level 3 PSA calculation for several SA and DBA as sensitivity analysis of pH control -Level 3 PSA calculation including external hazards.	4 November 2016
A4				A Strategy for Consideration of Chemistry Effects in UK ABWR Fault Studies (RO-0066) (TBD)	-Final claim and arguments for suppression pool pH -Summary of iodine chemistry in accident for UK-ABWR	30 November 2016
A1-A4	Generic PCSR Chapter 23 " Reactor Chemistry (Revision B)" (WPE-GD-0058)	-Claim and arguments for suppression pool pH -Type of evidence for iodine chemistry claims and arguments STEP 4	23 August 2015	Generic PCSR Chapter 23 " Reactor Chemistry (Revision C)" (WPE-GD-0058)	-Final claim and arguments for suppression pool pH	30 June 2017

Programme Milestones/ Schedule :
See attached Gantt Chart (Table 1).

Reference:
[1] GA91-9101-0101-23000, WPE-GD-0058 – UK ABWR GDA – Generic PCSR Chapter 23: Reactor Chemistry, Revision A, 22 August 2014. TRIM 2014/317546. [2] GA91-9101-0003-00451, WPE-GD-0097 – UK ABWR GDA – Suppression Pool pH Model during Severe Accident, Revision 0, 23 December 2014. TRIM 2014/474620. [3] NRC, "Iodine Chemical Forms in LWR Severe Accidents", NUREG-CR-5732 (1992)

Table 1 RO-ABWR-0043 Gantt Chart

Level	Action Title	Start(Plan)	Finish(Plan)
1	Regulator's issue of RO	09-Mar-15	31-Mar-15
1.1	ONR Issue RO	09-Mar-15	16-Mar-15
1.2	Hitachi-GE Acknowledge RO & Issue Resolution Plan	16-Mar-15	15-May-15
1.3	Regulator's confirm credibility of Resolution Plan	16-May-15	22-May-15
1.4	Regulator's publish RO and Resolution Plan	23-May-15	31-May-15
2	Preparation of Submissions and Closure of RO Actions	08-Apr-15	30-Nov-16
2.1	RO Action 1	08-Apr-15	04-Nov-16
2.2	RO Action 2	08-Apr-15	10-Jul-15
2.3	RO Action 3	08-Apr-15	04-Nov-16
2.4	RO Action 4	01-Jun-15	04-Nov-16
3	Regulator's Closure of RO	10-Jul-15	28-Feb-17
3.1	Regulator's assessment of RO	10-Jul-15	14-Feb-17
3.2	Regulator's publication of RO closure letter	15-Feb-17	28-Feb-17



*1: This will be conducted as part of the resolution plan for RO-ABWR-0066 and issued in the Topic Report termed the Strategy Report.
RO-ABWR-0043 Action1 close date is 30th November based on RO-ABWR-0066 Gantt Chart.
*2: This will be conducted as part of the resolution plan for RO-ABWR-0066 and issued in the Topic Report termed the Study Report.
RO-ABWR-0043 Action3 close date is 4th November based on RO-ABWR-0066 Gantt Chart.