REGULATORY OBSERVATION

REGULATOR TO COMPLETE

RO unique no.:	RO-ABWR-0043
Date sent:	16th March 2015
Acknowledgement required by:	8th April 2015
Agreement of Resolution Plan Required by:	*To be determined by the Hitachi-GE resolution plan.*
Resolution of Regulatory Observation required by:	*To be determined by the Hitachi-GE resolution plan.*
TRIM Ref.:	2015/99649
Related RQ / RO No. and TRIM Ref. (if any)**:**	RQ-ABWR-0332 & RQ-ABWR-0409
Observation title:	Demonstration of the adequacy of pH control in the Suppression Pool during accident conditions
Technical area(s) 9. Reactor Chemistry	**Related technical area(s)** 5. Fault Studies 18. Severe Accident Analysis 4. PSA

Regulatory Observation

SUMMARY

The objective of this Regulatory Observation (RO) is to state ONR's expectations with respect to Hitachi-GE demonstrating that the claims made in the Pre-construction Safety Report (PCSR) [1] relating to suppression pool pH control during accident conditions are adequately substantiated.

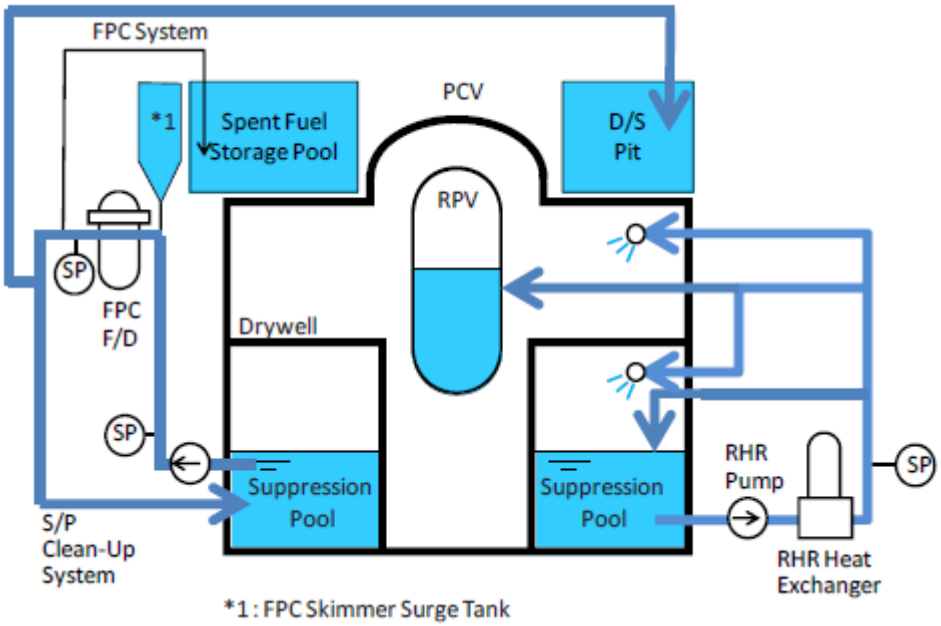
The PCSR for UK ABWR makes a fundamental safety claim that the water contained within the suppression pool retains a significant fraction of iodine releases during accident conditions. Iodine is of particular relevance due to its radiotoxicity. This claim is based upon the pH being maintained above a specific value. The Requesting Party (RP) therefore claims that chemistry control within the suppression pool minimises radioactive releases So Far As Is Reasonably Practicable (SFAIRP). However, 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.

As part of the Step 2 and Step 3 assessment of reactor chemistry for UK ABWR, ONR have been examining the validity of this claim and the supporting evidence to substantiate it. In response, Hitachi-GE provided a report which contains a calculation for the potential pH change in the suppression pool of a Japanese ABWR (J ABWR) under a pessimistic severe accident scenario [2]. The results of this calculation suggest that it would be difficult for Hitachi-GE to substantiate the claims currently made in the PCSR.

This RO has therefore been raised to clarify ONR's regulatory expectations regarding what further evidence is required to understand the safety significance, likelihood and potential consequences for pH changes in the suppression pool. The RO also explains how ONR expect this evidence to be used by the RP in their demonstration that the UK ABWR design does indeed reduce the risks associated with this phenomenon SFAIRP.

BACKGROUND

The suppression pool of UK ABWR is shown schematically in Figure 1, below.



KEY: SP = Sampling Point; S/P = Suppression Pool; FPC = Fuel Pool Cooling system; F/D = Filter Demineraliser; RPV = Reactor Pressure Vessel; PCV = Primary Containment Vessel; D/S = Dryer Separator, RHR = Residual Heat Removal system.

Figure 1: Schematic of the Suppression Pool and related systems

The suppression pool is a large volume, steel lined water store located at the bottom of the Primary Containment Vessel (PCV) that has functions during both normal operations and accident conditions. The pool contains demineralised water, which can be further purified using the SFP demineralisers. In normal operations the pool is the water source for filling the reactor well during refuelling and can also be the water source for other systems in certain conditions, such as the Residual Heat Removal (RHR) system. During an accident the water in the pool can be used:

- to quench steam released into the drywell by the reactor (either via the drywell connecting vents or drywell sprays);
- as a make-up coolant source; and
- to trap iodine releases in cases of fuel failures.

During accidents, when the main chemistry function of the suppression pool water is to minimise volatile iodine release the PCSR [1] describes the chemistry control requirements. These relate to maintenance of an adequate pH which would ensure most of the iodine remains in the water phase. There is therefore one explicit claim made for this system in Ref. 1:

> "Suppression pool chemistry reduces the release of radioisotopes from the Reinforced Concrete Containment Vessel (RCCV) so far as is reasonably practicable during accident scenarios."

The basis for this claim is that as long as the pH of the suppression pool is above pH 5.5 then the partition coefficient of iodine is greater than 100 (in other words more than 99% of the iodine is retained within the suppression pool water). Further details of this are given in my Step 2 assessment report [3]. One of the conclusions from this assessment was that, based on the information presented by the RP to date, I did not judge that the chemistry regime proposed for the suppression pool reduces risks SFAIRP and I noted that further evidence would be required to substantiate this claim.

In order to provide further evidence to support this claim the RP provided an evaluation of suppression pool pH during accident conditions [2]. Ref. 2 calculates the pH change in the suppression pool of a Japanese ABWR (J ABWR) during a severe accident based upon the information contained in NUREG-1465 [4]. Taken at face value, the results of this evaluation show that the pH of the suppression pool may drop below the pH 5.5 claimed in the PCSR, within only a few hours of the accident starting. However, there are many assumptions and simplifications in this analysis and as a consequence, while I am satisfied that the trend may

be realistic, I remain uncertain over whether the scale and timeframe for the pH change suggested are appropriate. The analysis also only considers what appears to be a very pessimistic severe accident scenario and provides no information on the consequences for the pH change observed. Furthermore, ref. 2 provides no explanation of the applicability of the results for J ABWR to the UK ABWR design.

REGULATORY EXPECTATIONS

Overall, while the evidence provided to date is useful in providing further qualitative information on the potential behaviour of the suppression pool in UK ABWR, in order to fully substantiate the claim made in the PCSR I require further evidence to understand the safety significance, likelihood and potential consequences for pH changes in the suppression pool. Based upon this information I will then require a demonstration that the design does indeed reduce the risks associated with this phenomenon SFAIRP.

I will therefore require further information to be provided in order to understand the significance of this claim and be satisfied that it can be adequately substantiated, including:

- As the suppression pool in UK ABWR is unbuffered the pH will be dominated by chemical species introduced during an accident, for example from fuel degradation products. These will include a wide range of species that could be both acidic or basic in nature. Any argument based on pH would need to consider these appropriately;
- The behaviour and speciation of iodine during the accident would be important, given the function of the pH control is to mitigate iodine releases, particularly if volatile organic iodine species form that are difficult to remove;
- The evidence which supports the claimed behaviour of iodine will need to be demonstrated to be suitable for conditions in UK ABWR (for example, under nitrogen atmospheres as opposed to air) and consistent with the current understanding of iodine behaviour in post-accident containments;
- How this phenomena fits within the overall safety case for accidents in UK ABWR, including the significance of this claim and when it may be needed; and
- The RP will need to present robust arguments and evidence to justify that the approach adopted for UK ABWR meets relevant good practice and reduces risks SFAIRP. [5] indicates that it is well-known that minimising volatile iodine requires the water solution containing iodine to be basic (pH > 7) as opposed to mildly acidic as suggested for UK ABWR.

The Regulatory Observation Actions given below are therefore structured in such a way to provide this information in a logical and step wise manner, to facilitate the ONR assessment.

References:

[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] GDA Step 2 Assessment of the Reactor Chemistry of Hitachi GE's UK Advanced Boiling Water Reactor (UK ABWR), ONR-GDA-AR-14-009, Revision 0, 28 August 2014. www.onr.org.uk/new-reactors/uk-abwr/reports/step2/uk-abwr-reactor-chemistry-step-2-assessment-executive-summary.pdf
[4] Accident Source Terms for Light-Water Nuclear Power Plants, NUREG-1465, US NRC, February 1995. http://pbadupws.nrc.gov/docs/ML0410/ML041040063.pdf

[5] State of the Art Report on Iodine Chemistry, NEA/CSNI/R(2007)1, OECD NEA, February 2007. www.oecd-nea.org/nsd/docs/2007/csni-r2007-1.pdf

Regulatory Observation Actions

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.*

The response to this Action should be clear on what claims and arguments are being made on pH control of the suppression pool in UK ABWR under accident conditions. This should include what the specific claims associated with the pH are, what the supporting arguments are and what accident scenarios require those claims to be made (including both design basis and severe accidents). Consideration needs to be given to potential downstream mitigations should the suppression pool not be claimed for iodine retention (for example, venting via a filtered vent route).

In responding to this Action, ONR would expect Hitachi-GE to consider whether similar claims are made for other BWRs and whether similar effects are considered.

The response to this Action may be combined with any other Action under this RO, if deemed appropriate.

RESOLUTION REQUIRED BY: to be determined by the Hitachi-GE resolution plan.

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

Based upon the response to Action 1, Hitachi-GE should provide an evaluation of the resultant pH change over time within the suppression pool of UK ABWR. The evaluation should be consistent with the fault analysis within the UK ABWR safety case. All chemical species which could affect the pH of the suppression pool should be considered. The calculation method should include an appropriate degree of conservatism depending upon the particular accident scenario under consideration (for example; conservative for DBA, best estimate for severe accidents). The response should be clear on the assumptions made within the analysis and should justify the adequacy of the approach taken, particularly with respect to the processes which change the pH.

Dependent upon the response to Action 1 it is possible that more than one calculation may need to be provided, although it may be possible to provide calculations which cover more than one accident scenario.

The response to this Action may be combined with any other Action under this RO, if deemed appropriate.

RESOLUTION REQUIRED BY: to be determined by the Hitachi-GE 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 defined under Action 2.*

Based upon the pH changes determined in response to Action 2, Hitachi-GE should provide an evaluation of the radiological consequences for the identified accident scenarios. Hitachi-GE may be able to group or bound the various accident scenarios to minimise the scope of work required. The consequences of assuming that the pH change is unmitigated and mitigated to >pH7 should be provided for comparison. The response should be clear on the assumptions made within the analysis and should justify the adequacy of the approach taken, particularly with respect to the behaviour of iodine.

The response to this Action may be combined with any other Action under this RO, if deemed appropriate.

RESOLUTION REQUIRED BY: to be determined by the Hitachi-GE resolution plan.

RO-ABWR-0043.A4 *– Hitachi-GE are required to provide a justification that the pH control arrangements for the suppression pool in UK ABWR reduces risk So Far As Is Reasonably Practicable (SFAIRP), based upon the responses to Actions 1 to 3.*

Based upon the safety significance, likelihood and potential consequences for pH changes in the suppression pool provided in Actions 1 to 3, Hitachi-GE should provide a demonstration that the UK ABWR design reduces the relevant risks associated with this phenomenon SFAIRP. If this evaluation determines that further mitigating measures are required then a plan and programme for developing the necessary proposals should be provided.

The response to this Action may be combined with any other Action under this RO, if deemed appropriate.

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:	