Hitachi-GE Nuclear Energy, Ltd.
UK ABWR GENERIC DESIGN ASSESSMENT
Resolution Plan for RO-ABWR-0034

Demonstrating the inclusion of a 'bottom drain line' in the UK ABWR design achieves inherent safety and reduces risks SFAIRP

RO TITLE:	Demonstrating the inclusion of a 'bottom drain line' in the UK ABWR design achieves inherent safety and reduces risks SFAIRP	
REVISION :	1	
Overall RO Closure Date (Planned):		31 March 2017
REFERENCE DOCUMENTATION RELATED TO REGULATORY OBSERVATION		
Regulatory Queries	RQ-ABWR-0082	
Linked ROs	-	
Other Documentation	-	

Scope of work :

Background

Rev. 0

The UK ABWR currently includes a design feature referred to as the 'bottom drain line'. The line is located at the bottom of the RPV and is connected to the CUW, as depicted in Figure 1 below as the line appearing as an arrow at the bottom of the RPV:

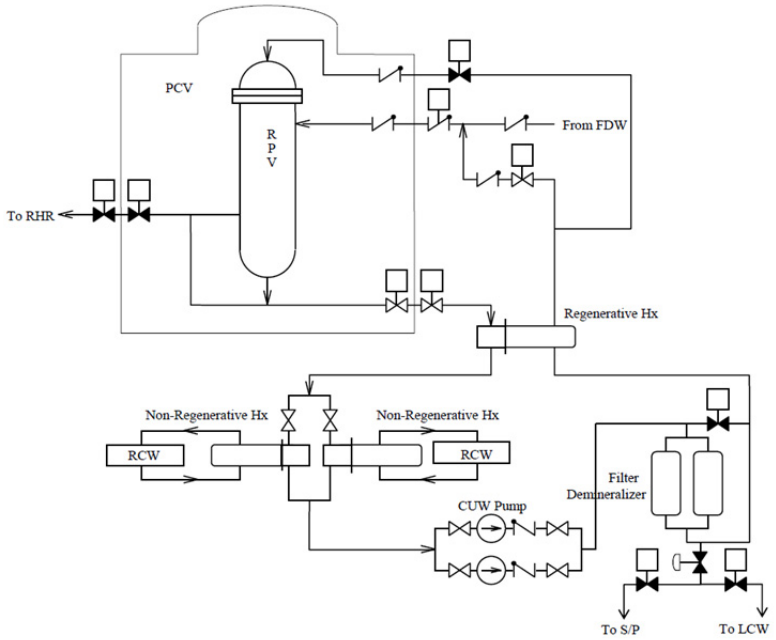

Figure 1: Depiction of the CUW for UK ABWR [Ref-0-3]

During Step 2 of GDA of UK ABWR, RQ-ABWR-0082 was raised in the reactor chemistry area which requested Hitachi-GE to explain:

- What the function(s) of the 'bottom drain line' in the UK ABWR design is(are), and based on their response to question 1, to provide:
- A justification that the presence of a 'bottom drain line' in the UK ABWR design reduces risks SFAIRP.

The reason for this RQ was that ONR understood that the drain line is a significant contributor to operator dose during outages, and at that time Hitachi-GE were considering material changes to this line as a measure to mitigate the dose.

Hitachi-GE provided a response to RQ-ABWR-0082 during Step 2. The underlying reasons given for inclusion of this feature in the design relate to corrosion product accumulation and thermal effects in the RPV. During the close-out of the reactor chemistry Step 2 assessment, ONR accepted Hitachi-GE's response to RQ-ABWR-0082 as being commensurate with the level of detail and justification expected at that stage of the GDA process, but informed Hitachi-GE the inclusion of a 'bottom drain line' in the UK ABWR design would be subject to further regulatory scrutiny as GDA progressed.

ONR has subsequently undertaken further assessment work related to this aspect of the design, the outcome of which confirms that such features are significant sources of dose and also challenges the reasons originally put forward for the inclusion of the 'bottom drain line' for UK ABWR. In summary, ONR has found that:

a. All German Boiling Water Reactors (BWRs) have permanently closed the drain openings at the RPV bottom [Ref-0-4];
b. All Swedish BWRs that were originally designed with a 'bottom drain line' have now permanently closed them, principally because;

    - Operating Experience Feedback (OPEX) has shown the line was not required in practice and was a large contributor to worker dose uptake during the outage;
    - The line was originally intended to drain CRUD (Chalk River Un-identified Deposit) which may accumulate in the bottom of the RPV, but OPEX showed CRUD accumulation did not prove problematic [Ref-0-5].

c. The design of all Swedish internally pumped BWR plants (similar to the UK ABWR design) does not include a 'bottom drain line' [Ref-0-5];
d. Some BWRs in the United States of America (USA) have also permanently closed the drain openings at the RPV bottom;
e. Water chemistry control for the UK ABWR is claimed to minimise the formation of CRUD [Ref-0-6].

This RO has therefore been raised to make clear ONR's expectations regarding Hitachi-GE's justification for the inclusion of a 'bottom drain line' in the UK ABWR, specifically whether this achieves an inherently safe design which avoids radiological hazards rather than controlling them, and whether its presence reduces risks SFAIRP.

REGULATORY EXPECTATIONS.

One of the main sources of standards and guidance ONR use in assessing the UK ABWR are the Safety Assessment Principles (SAPs) [Ref-0-7].

As outlined in SAP EKP.1, the engineering key principle covering inherent safety, ONR's preference is for an inherently safe design, which avoids radiological hazards rather than controlling them. The application of this principle is particularly important for a new facility at the design stage.

ONR expect Hitachi-GE to provide a robust demonstration that the inclusion of a 'bottom drain line' in the UK ABWR design achieves inherent safety and reduces risks SFAIRP. ONR expect first and foremost, the safest option to be selected, unless it can be shown it is not reasonably practicable for that option to be implemented.

ONR would expect Hitachi-GE to demonstrate:

- whether other options have been considered;
- to identify and document those options;
- to provide robust evidence of the criteria used in decision making and option selection, and;
- to provide evidence of gross disproportion in terms of cost (time, trouble or money) for options not selected.

In order to be able to undertake the above demonstration ONR would expect Hitachi-GE to:

- Take account of all relevant, Worldwide OPEX, regarding the purpose and function of the 'bottom drain line' in other BWRs;
- Clearly state the applicability, or otherwise, of the above Worldwide OPEX to the UK ABWR design;
- Clearly state all of the operational and safety functions of the 'bottom drain line' in the UK ABWR, including the consequences for its removal;
- Take due account of the claims being made on water chemistry control, or in other technical areas, for UK ABWR;
- Provide supporting evidence to demonstrate that the selected option has reduced risks SFAIRP.

Although this RO has been raised by the reactor chemistry topic, ONR's Radiation Protection (RP) discipline will lead the assessment of the response, with support from reactor chemistry and structural integrity, as required and as a minimum. ONR expect a similar coordinated approach to be adopted by Hitachi-GE in response to this RO.

Rev. 1
The ALARP justification document, SE-GD-0241 [Ref-1-3], was submitted along with a step-by-step approach described in the Resolution Plan [Ref-1-2]. The following summarises the recent interactions with ONR:

- Revision 0 was submitted in March 2015 and described the BDL design.
- Revision 1 was submitted in May 2015 and included the ALARP justification of the BDL design for the UK ABWR.
- A discussion was held between ONR and Hitachi-GE on Rev.1 of the ALARP report [Ref-1-3] during a L-4 video conference on 12th of June 2015 where the ONR suggested several improvements for consideration.
- Hitachi-GE received the ONR formal comments on Rev 1 of the report by letter (REG-HGNE-0096R) [Ref-1-4].
- ONR and Hitachi-GE discussed this RO-34 at the Reactor Chemistry L-4 video conference on 14th July 2015. Hitachi-GE understands the gap between what has been included in the reports compared to the ONR expectations.

This updated resolution plan is provided to describe the proposed recovery plan from Hitachi-GE in response to REG-HGNE-0096R
[Ref-1-4].

Description of work:

Rev. 0
Hitachi-GE is going to review and re-organise the overall ALARP justification process for the BDL with the following Recovery Actions (RAs).
Corresponds to RO-ABWR-0034, HGNE has established an RO action which consists of four sub-actions described below;

Action # 1:
Sub Action # 1-1 *: Fact Finding*
Hitachi-GE will organise the fact of RPV bottom drain line (BDL) especially the ones listed below;

- Detail design description of the BDL
- Safety function of the BDL

- Faults and Hazards caused by the BDL and their consequences
- Role of the BDL in the decommissioning work
- Dose impact from the BDL
- World wide Operation Experiences (OPEX) (if it is available)
- Pros and Cons in two cases, one is the case in which the BDL exists, and the other is the case in which it is removed.
- Commercial, performance and construction function of the BDL (not indispensable)

Resolution Date:
Sub action 1-1: 31st March 2015

Sub Action # 1-2 *:Consideration of alternatives*
Hitatchi-GE will consider the alternatives for the BDL removed case
- List up alternatives for each function of the BDL
- Assess the feasibility of each alternative

Resolution Date:
Sub action 1-2: 29th May 2015

Sub Action # 1-3 *: Design and management optimisation to reduce the amount of dose caused by the BDL*
Hitachi-GE will consider the countermeasures to reduce the impact of crud and amount of dose caused by the BDL for the BDL existing/removed case from material, reactor chemistry, piping route, shielding, maintenance view.
- Methods to reduce the amount of crud
- Methods to reduce dose rate of the BDL area and work time
- Other methods to reduce the amount of dose

Resolution Date:
Sub action 1-3: 29th May 2015

Sub Action # 1-4 *: ALARP/SFAIRP assessment, conclusion*
Hitachi-GE will assess the BDL design under consideration of Action 1 to 3 from ALARP/SFAIRP view
- Conclusion whether to remove the BDL or not
- If necessary, establish design change or maintenance procedure change recommendation

Resolution Date:
Sub action 1-4: 29th May 2015

Rev. 1
Following Recovery Actions will be taken to provide further information for the safety assessment of the BDL.

RA1: List the BDL related functions
The current ALARP justification document [Ref-1-3] describes the BDL related functions within the constraints of the current design (i.e. with the BDL in place). Hitachi-GE will undertake additional activities to underpin the ALARP study for the BD, such as, a review of the functions, the links to the High level Claims and links to other disciplines in GDA.

RA2: Set criteria on ALARP evaluation
Hitachi-GE will review and confirm the criteria or risk indicator used to undertake the BDL ALARP study to ensure it is comprehensive and consistent with the Hitachi-GE ALARP methodology document [Ref-1-5].

RA3: List design options for each function

Hitachi-GE will undertake a further review of Worldwide OPEX in order to ensure all design options are included within the study. Although the majority of BWRs in the world have a BDL, Hitachi-GE is aware that BWRs without a BDL exist in Europe (e.g. Sweden) Hitachi-GE will include these alternate options within the ALARP study.

RA4: Option study
On the basis that new and revised information will have been developed in RA1 to 3, the optioneering study will be revisited in order to ensure all aspects (e.g. functions and design options) are considered.

RA5: ALARP justification
Following the options study, the chosen design option will be reviewed to confirm overall risks has been reduced SFAIRP with a comparison to Worldwide OPEX,

Timeline
The updated timeline is provided as the chart of Table-1. Interaction meeting will be undertaken at the end of each RA.

Summary of impact on GDA submissions:

GDA Submission Document		Submission Date to ONR
ALARP Consideration on RPV Bottom Drain Line	**(GA91-9201-0003-00523)**	**Rev.0, 31st Mar 2015, Action #1-1**
ALARP Consideration on RPV Bottom Drain Line	**(GA91-9201-0003-00523)**	**Rev.1, 29st May 2015, Action #1-2 to #1-4**
PCSR chapter 7 (Internal Hazard)	(GA91-9201-0001-00007)	Rev.B, 23rd Aug 2015 (if necessary)
PCSR chapter 8 (Structural Integrity)	(GA91-9201-0001-00008)	Rev.B, 23rd Aug 2015 (if necessary)
PCSR chapter 12 (Reactor Coolant Systems, Reactivity Control Systems and Associated Systems)	(GA91-9201-0001-00012)	Rev.B, 23rd Aug 2015 (if necessary)
PCSR chapter 14 (Control and Instrumental)	(GA91-9201-0001-00014)	Rev.B, 23rd Aug 2015 (if necessary)
PCSR chapter 20 (Radiation Protection)	(GA91-9201-0001-00020)	Rev.B, 23rd Aug 2015 (if necessary)
PCSR chapter 23 (Reactor Chemistry)	(GA91-9201-0001-00023)	Rev.B, 23rd Aug 2015 (if necessary)
PCSR chapter 24 (Design Basis Analysis)	(GA91-9201-0001-00024)	Rev.B, 23rd Aug 2015 (if necessary)
PCSR chapter 25 (Probabillistic Safety Analysis)	(GA91-9201-0001-00025)	Rev.B, 23rd Aug 2015 (if necessary)
PCSR chapter 28 (ALARP Evaluation)	(GA91-9201-0001-00028)	Rev.B, 23rd Aug 2015 (if necessary)
PCSR chapter 31 (Decommissioning)	(GA91-9201-0001-00031)	Rev.B, 23rd Aug 2015 (if necessary)
Basis of Safety Cases on Reactor Water Clean-up System	(GA91-9201-0002-00014)	Rev.1, 23rd Aug 2015 (if necessary)

Programme Milestones/ Schedule:

Rev. 0 and 1
See attached Gantt Chart (Table 1).

Reference:

[Ref-0-1] Office for Nuclear Regulation, "GDA Regulatory Query RQ-ABWR-0082 - RPV Bottom Drain Line", March 2014.
[Ref-0-2] Hitachi-GE Nuclear Energy, Ltd., "UK ABWR GDA - Reactor water clean-up system design: RPV Bottom Drain Line (response to RQ-ABWR-0082)", GA91-9201-0003-00100(SE-GD-0096) rev. 0, May 2014.
[Ref-0-3] Hitachi-GE Nuclear Energy, Ltd., "UK ABWR GDA - ABWR General Description", GA91-9901-0032-00001(XE-GD-0126) , revision 1, Dec 2013.
[Ref-0-4] GRS, "Compilation of Boiling Water Reactors (BWR) operational experience (OpEx) to inform ONR's ABWR GDA assessment work during GDA - Final Report", July 2014.
[Ref-0-5] Office for Nuclear Regulation, "ONR-GDA-CR-14-202 - Level 4 Information Exchange Meeting with the Swedish Nuclear Safety Regulator (SSM) and Swedish Utilities on Boiling Water Reactor (BWR) Chemistry and Design", November 2014.
[Ref-0-6] Hitachi-GE Nuclear Energy, Ltd., "UK ABWR GDA - Preliminary Safety Report on Reactor Chemistry", GA91-9901-0041-00001(XE-GD-0152), Revision B, May 2014.
[Ref-0-7] Office for Nuclear Regulation, "Safety Assessment Principles for Nuclear Facilities 2014 Edition", Revision 0.
[Ref-1-1] Office for Nuclear Regulation, "Demonstrating the inclusion of a 'bottom drain line' in UK ABWR design achieves inherent safety and reduces risks SFAIRP" (Regulatory Observation, RO-ABWR-0034, December 2014)
[Ref-1-2] Hitachi-GE Nuclear Energy, Ltd., "Resolution Plan for RO-ABWR-0034 "Demonstrating the inclusion of a 'bottom drain line' in UK ABWR design achieves inherent safety and reduces risks SFAIRP", GA91-9201-0004-00036 (XE-GD-0306) rev. 0, February 2015.
[Ref-1-3] Hitachi-GE Nuclear Energy, "ALARP Consideration on RPV Bottom Drain Line", GA-91-9201-0003-00523(SE-GD-0241) rev. 0 and 1, March 2015 (rev. 0) and May 2015 (rev. 1).
[Ref-1-4] Office for Nuclear Regulation, Ltd., "Response to Regulatory Observation RO-ABWR-0034 and associated Regulatory Observation Action 1", REG-HGNE-0096R, July 2015.
[Ref-1-5] Hitachi-GE Nuclear Energy, Ltd., "GDA ALARP methodology", GA10-0511-0004-00001 (XD-GD-0037) rev. 1, November 2015.

Table 1 RO-ABWR-0034 Gantt Chart

UK ABWR Resolution Plan for RO-ABWR-0034 "Demonstrating the inclusion of a 'bottom drain line' in the UK ABWR design achieves inherent safety and reduce risks SFAIRP"				2014	2015												2016												2017		
				Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Level	Action Title	Start	Finish																												
1	**Regulator's issue of RO**																														
1.1	**ONR issue RO**	16-Dec-14	16-Dec-14																												
1.2	**Hitachi-GE acknowledge RO & issue Resolution Plan**	16-Dec-14	06-Feb-15																												
1.3	**Regulator's confirm credibility of Resolution Plan**	06-Feb-15	23-Feb-15																												
1.4	**Regulator's publish RO and Resolution Plan**	23-Feb-15	27-Feb-15																												
2	**Preparation of Submissions and Closure of RO Actions**																														
2.1	**ROA1**	02-Feb-15	29-May-15																												
2.1.1	**Sub Action 1-1 (Fact Finding)**	02-Feb-15	31-Mar-15																												
2.1.2	**Sub Action 1-2 (Alternative consideration)**	01-Apr-15	29-May-15																												
2.1.3	**Sub Action 1-3 (Method consideration of reducing dose)**	01-Apr-15	29-May-15																												
2.1.4	**Sub Action 1-4 (ALARP/SFAIRP evaluation)**	01-Apr-15	29-May-15																												
2.2	**RAs**																														
2.2.1	**RA1 List the BDL related functions**	15-Aug-15	31-Oct-15																												
2.2.2	**RA2 Set criteria**	01-Sep-15	30-Nov-15																												
2.2.3	**RA3 List options**	15-Aug-15	12-Feb-16																												
2.2.4	**RA4 Option study**	12-Feb-16	13-May-16																												
2.2.5	**RA5 ALARP justification**	13-May-16	10-Jun-16																												
2.2.6	**RA6 Topic report provision**	10-Jun-16	05-Aug-16																												
3	**Regulator's Closure of RO**																														
3.1	**Regulator's Assessment for ROA1**	01-Jun-15	15-Aug-15																												
3.2	**Regulator's Assessment for RAs**	05-Aug-16	31-Mar-17																												
3.3	**Regulator's publication of RO closure letter**	31-Mar-17	31-Mar-17																												