Hitachi-GE Nuclear Energy, Ltd.
UK ABWR GENERIC DESIGN ASSESSMENT
Resolution Plan for RO-ABWR-0061
Reactor Pressure Vessel Instrumentation Connections

RO TITLE:	Reactor Pressure Vessel Instrumentation Connections	
REVISION :	0	
Overall RO Closure Date (Planned):		31st January 2017
REFERENCE DOCUMENTATION RELATED TO REGULATORY OBSERVATION		
Regulatory Queries	RQ-ABWR-0436	
Linked ROs	-	
Other Documentation	-	

Scope of work :

Background

The ONR has raised RO-ABWR-0061 in respect of the Reactor Vessel Instrumentation and the follow up work undertaken in GDA Step 3 on the susceptibility of the common cause failure of the two sets of 4 impulse lines that are shared by the plant control system (PCntlS), safety system logic control (SSLC) and the hardwired back-up system (HWBS) to provide the means of level and pressure measurement. ONR has identified Topic Report GA91-9201-0001-00056; Topic Report on the Reactor Pressure Vessel Instrument System that describes the current arrangement and have highlighted the statement in section 3.1:

"Common pressure taps / sensing lines are used for a number of the sensors in order to minimise the number of penetrations of the reactor pressure vessel";

and this and the associated C&I safety case does not provide an adequate justification of the use of common lines by Class 1, 2 and 3 systems.

ONR has identified the purpose of the RO as follows: *"The purpose of this regulatory observation is to provide guidance on the regulatory expectations of the connection of instrumentation to the RPV"*.

ONR has also identified SAP EDR.3 and its supporting explanatory paragraphs (184 – 187) as providing further information on use of redundancy and its limitations in making a high reliability claim, especially one that is better than 1 failure per 100 000 demands.

This resolution plan is Hitachi-GE's commitment to provide documentation describing a holistic safety justification that the RPV instrumentation system design will meet the requirements for independence and the common cause failure claimed for the UK ABWR in its safety case.

The current RVI instrumentation system architecture is based on a four division design, each with a set of three instrument impulse lines (each set has an upper and two lower lines) providing the means of connection to the RPV for

reactor pressure, narrow range and wide range level measurement. The upper impulse lines are used by SSLC, HWBS and PCntlS for pressure measurement and as the reference for the narrow and wide range level measurements. The narrow range level is used by the SSLC, HWBS and PCntlS while the wide range is used by the SSLC and HWBS. There are in addition 4 divisions of impulse lines providing a flow measurement by differential pressure across the reactor internal pump (RIP) deck and a further 4 divisions of impulse lines providing a flow measurement by differential pressure across the Core plate. The former are used by the PCntlS and the latter by both the SSLC.

In the current design several sensors are connected to each of the impulse lines to provide, on an individual basis, the signals used for the SSLC, HWBS and the PCntlS. The sensors measuring the reactor water level and pressure are selected to provide adequate diversity between the SSLC, the HWBS, and the PCntlS.
The key reason that the instrumentation impulse lines have been shared by several sensors is to minimise the loss of coolant accident (LOCA) risk by reducing number and length of the instrumentation impulse lines

However, Hitachi-GE has been reviewing the design of the instrumentation impulse lines design for the UK ABWR in terms of ensuring independence, diversity, and optimising segregation based on the ONR's regulatory expectations, in order to eliminate the potential susceptibility of the proposed design to common cause failures.

Scope of Work

The RO identified four key products and the scope of this RO has been developed to include each of these and to respond to the three actions set by the RO. Hitachi-GE will evaluate the current RPV instrumentation impulse lines design and will provide the results of its analysis, including a review of a number of different options, in suitable documentation as its response to this RO . Hitachi-GE will carry out holistic evaluations of the RPV instrumentation system design, including the measuring devices/equipment connected to the instrumentation impulse lines and will then submit the documents providing the evaluation results to ONR.
Hitachi-GE will carry out reviews of the RPV instrumentation impulse lines design using a combination of the Fault Analysis and Probabilistic Safety Analysis, and will demonstrate that the selected design option has sufficiently taken into account all sources of common cause failures. .

This Resolution Plan describes Hitachi-GE's plan to address the RO; however, as the work develops, it may be necessary to choose an alternative means to address RO-0061.

Description of work:

RO-ABWR-0061 Action 1 :

The RO action states that:

Hitachi-GE are to develop suitable documentation that includes a description of the optioneering studies that have been carried out to determine the form of the RVI instrumentation line used for pressure and level measurement. The optioneering should address how specifically common cause failures have been analysedin respect of their impact on pressure and level measurement and on the on the three major C&I systems.

Resolution required by:- October 2015

Hitachi-GE will carry out a holistic review of the design of the RVI instrumentation system as identified in key product 1 and will also review the defence against common cause failure mechanisms that will be identified in key product 2. The scope of this holistic review will include both parts of RO A1; that is a) the use of the same impulse lines by all three major C&I systems and b) the use of a common physical measurement, pressure, as both a direct input to the protection and control systems and as the basis for other measurements such as level and flow.

a) The use of the same impulse lines by all three major C&I systems

The work will be undertaken in 4 steps:

1

Hitachi-GE will evaluate the current RPV Instrumentation system design to show where it meets or challenges the independence requirement and that adequate considerations are given to common cause failures in the design. This work will be undertaken jointly by the C&I, Fault Studies (FS), Probabilistic Safety Analysis (PSA) and other discipline teams.

2

Hitachi-GE will identify the potential initiators of common cause failure mechanisms for all components of the RPV Instrumentation impulse line. The review will include the internal and external hazards, maintenance errors as well as aging degradation mechanisms that might affect the integrity of each component and its ability to deliver its required service.

This work will be undertaken jointly by the FS, PSA, ME, SI, RC, HF, IH and EH teams with C&I lead.

3

For each of the common cause failures mechanisms identified an exercise will be undertaken to identify the measures to avoid, reduce or mitigate them.

This work will be undertaken jointly by the FS, PSA, ME, SI, RC, HF, IH and EH teams with C&I lead.

4

A set of design options and an evaluation framework will be established for the totality of the mechanical equipment and sensors of the impulse lines. The framework will be used to evaluate each of the design options to be considered in addressing this RO. The output of the optioneering exercise will be used as the basis for

justifying the design of the RVI impulse lines. Noting that the detailed justification will be provided as part of RO A2.

Hitachi-GE will also use results of this work as input to the demonstration that the selected option is ALARP and has appropriate measures to avoid, reduce or mitigate CCF.

This work will be undertaken jointly by the FS, PSA, ME, SI, RC, HF, IH and EH teams with C&I lead.

b) The use of a common physical measurement, pressure, as both a direct input to the protection and control systems and as basis for other measurements such as level and flow.

Hitachi-GE will evaluate that the use of a common physical measurement, pressure as a direct input to the protection and control system and as a surrogate for other measurements such as level and flow. This work will be undertaken jointly by the C&I, FS, PSA and other discipline teams. The work will have 3 steps:

(1) A review of physical measurements of Class 1 and 2 systems

Hitachi-GE will review the physical measurement claimed by the Class 1 and 2 systems that are providing defence for each postulated initiating event identified in the Fault Schedule. The work will identify where the claimed defence relies on pressure or pressure as a surrogate measurement.

This work will be undertaken jointly by the C&I and FS teams.

(2) A justification of the use of a common physical measurement

Hitachi-GE will justify the use of the common physical measurement for each postulated initiating event identified from the Fault Schedule in (1) above. Hitachi-GE's means for doing this will be to diversify all sensor transmitters by showing each utilises a diverse physical process.

This work will be undertaken jointly by the C&I and FS teams.

(3) For completeness of the ALARP review, a set of studies will be undertaken seeking proposals for design changes to reduce the dependency on the common physical pressure measurement.

Hitachi-GE will carry out the option studies for potential design changes if the work explained above shows (1) that the common physical measurement of pressure will require an alternative physical measurement for the postulated initiating event identified in the Fault Schedule.

This work will be undertaken jointly by the FS, PSA, ME, SI, RC, HF, IH and EH teams with C&I lead.

FS: Fault Studies, PSA : Probabilistic Safety Analysis, ME: Mechanical Engineering , SI : Structural Integrity, RC: Reactor Chemistry , HF : Human Factors , IH : Internal Hazards , EH : External Hazards

RO-ABWR-0061 Action 2 :

Hitachi-GE is to develop suitable documentation that substantiates the proposed design of the RPV Instrumentation System in respect of C&I including the consequences of common cause failure. It is expected that the documentation

will follow the claims, arguments and evidence approach.

Resolution required by:- March 2016

Hitachi-GE will reflect the result of Actions 1 a) and 1 b) in the Basis of Safety Cases (BSC) on C&I Architecture using a claims, arguments and evidence approach. The Topic Report (TR) on Reactor Pressure Vessel Instrument System will be revised to include any changes in the design and the evidence to support additional claims made in the architecture BSC by early 2016. A fault studies / PSA report will be prepared to show where the requirements for independence are challenged by use of common impulse lines or use of pressure as a direct and surrogate measurement. The report will identify how this is to be included in the FS and PSA work.

The impact of the work on other disciples will be identified for inclusion in their BSCs / TRs as appropriate; e.g. the consequences of addition RPV penetrations and routing of additional sensing lines will be included in the structural integrity and mechanical engineering reports. The scope of this work and its impact on the safety case will be confirmed, e.g. by producing a document revision programme, once the outcome of RO-0061 A1 is confirmed.

This work will be carried out by C&I team with the support by the FS, PSA, ME, SI, RC, HF, IH and EH teams.

RO-ABWR-0061 Action 3 :

Hitachi-GE should confirm that the proposed design of the RPV impulse lines has been included in the safety cases for all affected topic areas including structural integrity, mechanical engineering, fault studies and PSA.
Resolution required by:- January 2017

Hitachi-GE will confirm that the additional work identified as part of Action 2 has been completed and included in the safety case for all affected areas. The delivery programme for this will be dependent on the agreement of the direction to be taken from the work of RO-0061 A1 and will be programmed as part of RO-0061 A2. This work will be undertaken jointly by the C&I, SI, ME, FS, PSA teams. Hitachi-GE will revise the safety case documents for all affected topic areas by January 2017.

Summary of impact on GDA submissions:

Related RO Actions	GDA Submission Document Title	Document ID (Document No.)	Submission Date to the Regulators
Submitted Document			
Action 3	Generic PCSR Chapter 14	GA91-9101-0101-14000,Rev. A	Early 2017
Action 2	BSC C&I Architecture	GA91-9201-0002-00022, Rev. 0	Early 2016
Action 2	BSC on Safety System Logic and Control System	GA91-9201-0001-00073, Rev.0	Early 2016
Action 2	TR on RVI system	GA91-9201-0001-00056, Rev. 0	Early 2016
Action 2	RVI System Diagram	GB21-2109-0001-00001, Rev.0	Early 2016
Action 3	*Fault Analysis Report*	TBD	June 2016
Action 3	*PSA Report*	TBD	June 2016
Action 3	Purchase Drawings for Reactor Pressure Vessel in GDA	GA91-9201-0003-00510, Rev.0	June 2016
Action 3	Purchase Specification for UK ABWR Reactor Pressure Vessel in GDA	GA91-9201-0003-00511, Rev.1	June 2016
Action 3	ASME Code Section III, Design Specification for Reactor Pressure Vessel in GDA	GA91-9201-0003-00269, Rev.1	June 2016
Action 3	Design Report for RPV	GA91-9201-0003-00274, TBD.	June 2016
Action 3	TR on RPV Structural Integrity	GA91-9201-0001-00076, Rev.0	June 2016
Action 3	BSC on Control Rod Drive System	GA91-9201-0002-00013 Rev.1	June 2016
Action 3	BSC on Emergency Core Cooling System	GA91-9201-0002-00020, Rev.0	June 2016
Action 3	BSC on Containment Isolation System	GA91-9201-0002-00076, Rev.0	June 2016
Planned Submissions			
Action 1	Optioneering Report	TBD (TBD)	October 2015

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

Reference:
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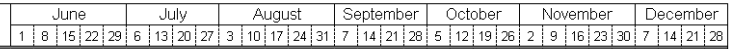
Table 1 RO-ABWR-0061 Gantt Chart

C&I Resolution Plan for RO-ABWR-00xx (2015)

Level	Action Title	Start	Finish
1	Preparation of Submissions and Closure of RO Actions	1-Jul-15	31-Jan-17
1.1	RO Action 1	1-Jul-15	31-Oct-15
1.2	RO Action 2	1-Oct-15	31-Mar-16
1.3	RO Action 3	1-Feb-16	31-Jan-17
2	Design Changes through 6 Step process	1-Jun-15	29-Feb-16



C&I Resolution Plan for RO-ABWR-00xx (2016)

Level	Action Title	Start	Finish
1	Preparation of Submissions and Closure of RO Actions	1-Jul-15	31-Jan-17
1.1	RO Action 1	1-Jul-15	31-Oct-15
1.2	RO Action 2	1-Oct-15	31-Mar-16
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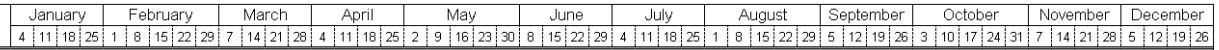

C&I Resolution Plan for RO-ABWR-00xx (2017)

Level	Action Title	Start	Finish
1	Preparation of Submissions and Closure of RO Actions	1-Jul-15	31-Jan-17
1.1	RO Action 1	1-Jul-15	31-Oct-15
1.2	RO Action 2	1-Oct-15	31-Mar-16
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