Hitachi-GE Nuclear Energy, Ltd.
UK ABWR GENERIC DESIGN ASSESSMENT
Resolution Plan for RO-ABWR-0044
(Demonstration UK ABWR has been designed to safely manage radiolysis gases generated under normal operations)

RO TITLE:	Demonstration UK ABWR has been designed to safely manage radiolysis gases generated under normal operations	
REVISION :	2	
Overall RO Closure Date (Planned):		28 February 2017
REFERENCE DOCUMENTATION RELATED TO REGULATORY OBSERVATION		
Regulatory Queries	RQ-ABWR-0080	
Linked ROs	-	
Other Documentation	"Countermeasures against radiolytic gases (Response to RQ-ABWR-0080)", GA91-9201-0003-00093, PE-GD-0002 Rev.0	

Scope of work :

Back ground

ONR issued Regulatory Query (RQ-ABWR-0080) regarding radiolytic gas generation and accumulation inside piping in March 2014 and Hitachi-GE responded the RQ with Engineering document (GA91-9201-0003-00093, PE-GD-0002 Rev.0)[Ref-1]. In addition, Hitachi-GE submitted the topic report (GA91-9201-0001-00106, PD-GD-0018, Rev.0) [Ref-2] to show the summary of JANTI Guideline [Ref-3] and ALARP evaluation for this application of the JANTI Guideline in comparison with guidelines of other countries, and Off-Gas System Basis of Safety Case (GE91-9201-0002-00054, GE-GD-0009, Rev.1) [Ref-4]. In March 2015, ONR issued RO (RO-ABWR-0044) requesting to show that UK ABWR has been designed to safely manage radiolytic gases generated under normal operations. This Resolution Plan is prepared to respond the RO-ABWR-0044.

Scope of work

This Resolution Plan shows actions and milestones for preparation to show that UK ABWR has been designed to safely manage radiolytic gases generated under normal operations. This describes Hitachi-GE's current plan to address the RO-ABWR-0044.

Description of work:

Hitachi-GE fully understand the potential risk posed by the generation of radiolytic gases within the UK ABWR. There is actual operating experience within Japan at the Hamaoka plant, in addition to our awareness of other events throughout the world and the research that has gone on within the nuclear industry and other industries trying to understand hydrogen hazards. The design of the UK ABWR addresses this issue.

In order to demonstrate this understanding, and demonstrate the UK ABWR design meets applicable regulations for safe hydrogen management, Hitachi-GE propose to prepare a Topic Report that documents how the UK ABWR design will safely manage the generation of radiolytic gases during normal operations. This report will cover all relevant modes of normal operations, including startup, shutdown, outage, and power operation and events that may be expected during normal operation. This report will not cover radiolytic gases generated during accident conditions

The Topic Report will present information about the generation of radiolytic gases expected in the UK ABWR using a risk assessment process consistent with the UK DSEAR regulations. Hitachi-GE will present information about radiolytic gas properties, mechanisms for generation, and behavior of gases during normal operation. Consistent with UK modern standards safety case practices, safety claims or performance functions of the UK ABWR will be presented relative to radiolytic gases as well.

A discussion of the relevant UK regulations and guidance to address radiolytic gas generation, accumulation and potential release will be described. Specifically, this section will include descriptions of the DSEAR regulations and the Japanese piping design guidance issued by JANTI to address radiolytic gas management.

The methodology for the risk assessment will be presented in the Topic Report. As discussed, this risk assessment process is consistent with the DSEAR regulations requirements. The method will 1) identify areas where radiolytic gases might be generated, contained, and accumulated; 2) describe how the risk is being reduced, either through prevention or mitigation, consistent with DSEAR and JANTI guidance, and 3) evaluate the worst case consequences in the event of an explosion, if applicable. As described in previous reports, the design intent of the UK ABWR is to minimize accumulation of radiolytic gases.

Using the methodology described previously, the Topic Report will identify UK ABWR systems with the potential to generate and/or contain radiolytic gases. The DSEAR and JANTI risk assessment processes will then be used to assess the risk caused by the radiolytic gases.

OPEX that deals with radiolytic gases will be reviewed by Hitachi-GE and assessed against the design features of the UK ABWR that prevent or mitigate these particular events. This review will ensure that the UK ABWR has incorporated any improvements from learning from past events.

The conclusion in the Topic Report will be a review of the UK ABWR against the DSEAR regulations, JANTI piping design guidelines, and relevant OPEX to provide a justification that the design reduces the risk as low as reasonably practicable.

Hitachi-GE propose to provide the Topic Report in progressive revisions that increase the details based on the progression of the detailed UK ABWR design. The UK ABWR design reference point will not be established until the end of the Step 3 so information about the design will not yet be completely available in order to deliver an assessment within Step 3. Because of this constraint, Hitachi-GE propose to use the Japanese ABWR design as a basis for example assessments during Step 3 to demonstrate the methodology. Hitachi-GE will justify this approach by making a comparison between the J ABWR and the UK ABWR to show they are the same or similar. For Step 4, Hitachi-GE will carry out assessments based on the UK ABWR design for the Reactor Building, Radwaste Building and the Turbine Building.

The Topic Report will be delivered in four milestones, or Revisions:

- Step 3: Revision 0 to be issued to ONR on 30 June 2015. This revision will include the background, description of the applicable regulations, risk assessment methodology, identification of UK ABWR systems with the potential to generate radiolytic hydrogen, and examples assessments of some of these systems, using the J ABWR as a basis. For better understanding of the methodology, the example assessments apply the methodology described above, consistent with the DSEAR regulations based on J ABWR design, the DSEAR Approved Code of Practice and JANTI guidance. Available OPEX will be reviewed.
- Step 4: Revision 1 to be issued to ONR on 29 January 2016. This revision will provide detailed assessments of the systems in the Reactor Building. This is consistent with the development of the UK ABWR piping design. Any additional OPEX gathered will be assessed and the design reviewed against it.
- Step 4: Revision 2 to be issued to ONR on 31 August 2016. This revision will provide detailed assessments of the systems in the Radwaste Building. Any additional OPEX gathered will be assessed and the design reviewed against it. For this revision, the detailed calculations underlying the assessment will be provided in a supporting document (SE-GD-0428), with the main Topic Report document providing the summary safety case arguments.
- Step 4: Revision 3 to be issued to ONR on 9 December 2016. This revision will provide detailed assessments of the systems in the Turbine Building and any other relevant buildings. Any additional OPEX gathered will be assessed and the design reviewed against it. As for Rev.3, detailed calculations will be provided in a separate supporting document (SE-GD-0428). A conclusion relative to reducing risk as low as reasonably practicable will be made.

In addition to the Topic Report, Hitachi-GE propose to issue an additional document to this Topic Report that describes the hydrogen explosion calculation methods that will be used to assess the consequences of a potential hydrogen explosion in areas where hydrogen may accumulate, if areas are identified that would develop a dangerous atmosphere, consistent with the DSEAR regulations and guidance. The basis for these calculation methods will be the JANTI guidelines, as well as other calculation methods developed specifically for hydrogen accumulation in piping. If hydrogen release from the pipework is expected and the concentration of hydrogen in the area of release is dangerous, then typical explosion calculations will be used. The context of the method will be provided through use of a small number of selected J ABWR or generic examples, with fuller and more specific examples to follow in the Topic Report. In order to provide some information consistent with the Step 3 overall submission schedule, Hitachi-GE propose to deliver this supporting document on 29 May 2015. The information in this additional document will also be included in the Topic Report.

The discussion below maps the information above to address the four Actions contained in the Regulatory Observation. Note that all the listed Hitachi-GE actions will be addressed for each plant location/building within each of the above Topic Report revisions.

RO-ABWR-0044.A1
Identification of all potential areas which may be susceptible to the formation of flammable atmospheres.

Hitachi-GE's actions;
Hitachi-GE will provide Topic Report on safe management of radiolytic gases generated under normal operations (SE-GD-0250), which include;

1). The applicable regulation and guidance (i.e. DSEAR [Ref-5], JANTI guidance [Ref-3]) for safety management of radiolytic gases generated under normal operations.
2). The identification of all potential areas which may be susceptible to the formation of dangerous atmospheres.

RO-ABWR-0044.A2
Implement of a consequence analysis based on a worst case unmitigated scenario.

Hitachi-GE's actions;
Hitachi-GE will provide a supporting document that describes the calculation methods used to assess hydrogen explosions inside and outside piping.

Hitachi-GE identify via the 'Main Document' (SE-GD-0250) and 'Supporting Document' (SE-GD-0428) all areas of 'process' and 'plant' which could accumulate radiolytic gases. The potential radiolytic gas explosion hazards have been assessed in Rev.1 of Detailed Analysis Fire Modelling and Barrier Response (BKE-GD-0048) Further consequence assessment will be completed for other areas if required.

RO-ABWR-0044.A3
Identification and implement of all reasonably practicable measures which have been taken to address the vulnerable areas.

Hitachi-GE's actions;
Hitachi-GE have provided Topic Report on safe management of radiolytic gases generated under normal operations (SE-GD-0250) and a supporting document (SE-GD-0428), which includes the explanation of the measures which are to be taken specifically for the UK ABWR design to: eliminate, reduce or mitigate the risks of radiolytic gas accumulation. Hitachi-GE will ensure that the Topic Report and supporting document show how the assessment and design addresses identified vulnerable areas, and provides ALARP justification for most of those areas. Separate to resolution of RO-ABWR-0044, Hitachi-GE are creating or making changes to a suite of ALARP assessments related to RO-ABWR-0036 and RO-ABWR-0073 workstreams to include the new information on radiolytic gas hazards output from RO-ABWR-0044. These documents are: ALARP Assessment for the Reactor Pressure Vessel Head Spray (SE-GD-0529), Topic Report on ALARP Assessment for Off-Gas System (GE-GD-0035) and Topic Report on ALARP Assessment for the UK ABWR LWMS and WILW/WLLW Systems (WE-GD-0057). The ALARP Assessment for the Reactor Pressure Vessel Head Spray has already been provided to ONR. The Topic Report on ALARP Assessment for Off-Gas System and the Topic Report on ALARP Assessment for the UK ABWR LWMS and WILW/WLLW System are due to be updated as part of the RO-ABWR-0036 and RO-ABWR-0073 work streams respectively, and the detailed actions and schedule for these Topic Reports will be shown in the Resolution Plans for RO-ABWR-0036 and RO-ABWR-0073.

RO-ABWR-0044.A4
Development the document which shows safety case, the risks and hazard presented by radiolytic gases under normal operation.

Hitachi-GE's actions;
Hitachi-GE have provided numerous revisions of the 'Main Document'(SE-GD-0250) and 'Supporting Document' (SE-GD-0428), which present the claims, arguments and evidence required to demonstrate the UK ABWR has been designed to safely manage radiolytic gases generated under normal operations. Rev.3 of the Main Document and Rev.1 of the Supporting Document will have assessed all relevant buildings that might include radiolytic gas hazard risk. These documents, along with documents to be delivered in RO-ABWR-0036 and RO-ABWR-0073 workstreams, represent the overall safety case for radiolytic gas hazards. As such, upon delivery of Rev 3 of SE-GD-0250 and Rev 1 of SE-GD-0428, Hitachi-GE will have provided the appropriate information for resolution of RO-ABWR-0044.

Summary of impact on GDA submissions:

GDA Submission Document	Submission Data to ONR
Topic Report on Safe management of radiolytic gases generated under normal operations, SE-GD-0250, Rev.0	30 June 2015
Topic Report on Safe management of radiolytic gases generated under normal operations, SE-GD-0250, Rev.1	30 January 2016
Topic Report on Safe management of radiolytic gases generated under normal operations, SE-GD-0250, Rev.2	31 August 2016
Supporting information for the Topic Report on safe management of radiolytic gases generated under normal operations, SE-GD-0428, Rev.0	31 August 2016
ALARP Assessment for the Reactor Pressure Vessel Head Spray, SE-GD-0529, Rev.0	31 October 2016
Detailed analysis of fire modelling and barrier response, BKE-GD-0048, Rev.1	31 October 2016
Topic Report on Safe management of radiolytic gases generated under normal operations, SE-GD-0250, Rev.3	9 December 2016
Supporting information for the Topic Report on safe management of radiolytic gases generated under normal operations, SE-GD-0428, Rev.1	9 December 2016
Generic PCSR Chapter 23 : Reactor Chemistry, GA91-9101-0101-23000, WPE-GD-0058, Rev.B	15 October 2015
Generic PCSR Chapter 23 : Reactor Chemistry, GA91-9101-0101-23000, WPE-GD-0058, Rev.C	31 August 2017

Programme Milestones/ Schedule :

See attached Gantt Chart (Table 1).

Reference:

[Ref-1] "Countermeasures against radiolytic gases (Response to RQ-ABWR-0080)" (GA91-9201-0003-00093, PE-GD-0002 Rev. 0)

[Ref-2] "Topic Report on methodology of radiolysis gases (including JANTI guideline) "(GA91-9201-0001-00106, PD-GD-0018 Rev.0)

[Ref-3]	"Design Guideline to Prevent the Pipe Rupture by combustion of Radiolysis Gases in BWR Steam Piping" (JANTI-NCG-01, the third edition, Japan Nuclear Technology Institute)
[Ref-4]	"Off-Gas System Basis of Safety Case" (GA91-9201-0002-00054, GE-GD-0009, Rev.1)
[Ref-5]	"The Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR) "
[Ref-6]	"Resolution Plan for RO-ABWR-0036 (Demonstration that the approach taken to radioactive waste management reduces risks SFIRP)" (GA91-9201-0004-00039, XE-GD-0314, Rev.2)
[Ref-7]	"Resolution Plan for RO-ABWR-0073 (Robust demonstration that the design of the UK ABWR off-gas system reduce risks SFAIRP)" (GA91-9201-0004-00073, GD-GD-0053, Rev.0)

Table 1 RO-ABWR-0044 Gantt Chart