

REGULATORY OBSERVATION

REGULATOR TO COMPLETE

RO unique no.:	RO-ABWR-0044
Date sent:	23rd March 2015
Acknowledgement required by:	15th April 2015
Agreement of Resolution Plan Required by:	<i>To be determined by Hitachi-GE Resolution Plan</i>
Resolution of Regulatory Observation required by:	<i>To be determined by Hitachi-GE Resolution Plan</i>
TRIM Ref.:	2015/59719
Related RQ / RO No. and TRIM Ref. (if any):	RQ-ABWR-0080; 2014/118048
Observation title:	Demonstration UK ABWR has been designed to safely manage radiolysis gases generated under normal operations
Technical area(s) 1. Internal Hazards 9. Reactor Chemistry	Related technical area(s) 11. Mechanical Engineering 5. Fault Studies

Regulatory Observation

SUMMARY

The objective of this Regulatory Observation (RO) is to make clear ONR's expectations for the approach taken by Hitachi-GE to address the generation, accumulation, management and mitigation of radiolysis gases, and the development of the associated safety justification for the United Kingdom Advanced Boiling Water Reactor (UK ABWR).

During Step 2 of the Generic Design Assessment (GDA) of UK ABWR, the reactor chemistry assessment [1] looked at aspects of the UK ABWR design from the perspective of managing radiolysis gases (H_2 and O_2) and subsequent treatment to remove these gases. RQ-ABWR-0080 was raised on the topic and a response received from Hitachi-GE [2]. One of the conclusions in Reference 1 was that this aspect should be followed-up by a multi-disciplinary team and further assessment undertaken during Step 3.

ONR's reactor chemistry and internal hazards inspectors have commenced the Step 3 follow-up work in this area. Based on our assessment so far, there is evidence to suggest UK ABWR may have been designed to take account of the need to safely manage radiolysis gases generated under normal operations, however Hitachi-GE's current approach is not yet complete and may not meet regulatory expectations for making an adequate safety case in the UK context.

This RO has therefore been raised to make clear ONR's expectations regarding Hitachi-GE's demonstration that UK ABWR has been designed to safely manage radiolysis gases generated under normal operations.

BACKGROUND

Inherent to the Boiling Water Reactor (BWR) design is the formation of hydrogen (H_2) and oxygen (O_2) in relatively large, stoichiometric quantities under normal operations, due to the radiolysis of water in the Reactor Pressure Vessel (RPV). Under certain conditions, it is possible for radiolytic gases to become enriched, creating potentially explosive mixtures of gases in plant piping or vessels. Furthermore, if radiolysis gases are able to escape, explosive atmospheres in rooms and enclosed spaces on the facility, external to the process, may form, giving rise to a consequential internal hazard. A number of events have occurred in the past at BWRs due to these phenomena.

During Step 2 of GDA of UK ABWR, the reactor chemistry assessment [1] looked at aspects of the UK ABWR design from the perspective of managing radiolysis gases (H_2 and O_2) and off-gas treatment. RQ-ABWR-0080 was raised on the topic and a response received from Hitachi-GE [2].

One of the conclusions in Reference 1 is that the generation, accumulation, management and mitigation of radiolysis gases during normal operations, and the development of the associated safety justification for the UK ABWR design, should be followed-up by a multi-disciplinary team and further assessment undertaken during Step 3.

ONR's reactor chemistry and internal hazards inspectors have commenced the Step 3 follow-up work in this area and have assessed two of Hitachi-GE's submissions:

1. Topic Report on Methodology of Radiolysis Gases (Including JANTI Guidelines) [3];
2. Revision 1 of the Off-gas System Basis of Safety Case [4].

Based on our assessment of References 2, 3 and 4, there is evidence to suggest that UK ABWR may have been designed to take account of the need to safely manage radiolysis gases generated under normal operations. For example, the requirements of generic Japanese industry standards and guidelines have been presented. Hitachi-GE's current approach, however, is not yet complete and may not meet regulatory expectations for making an adequate safety case in the UK context. Further information is required to demonstrate and justify how generic standards and guidance have been applied specifically to UK ABWR and to demonstrate the requirements of UK health and safety legislation have been met. In addition, Hitachi-GE may need to consider the manner in which these particular risks and hazards are documented and presented in the UK ABWR safety case.

This RO has therefore been raised to make clear ONR's expectations regarding Hitachi-GE's demonstration that UK ABWR has been designed to safely manage radiolysis gases generated under normal operations. It is important to note the RO is concerned with radiolysis gases generated under normal operations only. Management of H₂ for example, generated under fault or accident conditions is excluded from the scope of this RO.

REGULATORY EXPECTATIONS

This RO has been raised jointly by the reactor chemistry and internal hazards topics. ONR's expectations in both of these disciplines are aligned, in that ONR expects aspects of the UK ABWR safety case dealing with radiolysis gases under normal operations to:

- be specific to the UK ABWR design;
- adequately describe the risk, in terms of the extent of the hazard presented;
- adequately address all relevant aspects of UK health & safety legislation, specifically the requirements of the Dangerous Substances and Explosives Atmospheres Regulations (DSEAR) 2002 [5];
- adequately describe the measures that have been taken, specifically for the UK ABWR design, to: eliminate, reduce, or mitigate relevant risks;
- provide a demonstration all relevant risks have been reduced So Far as is Reasonably Practicable (SFAIRP).

When considering the above, ONR would expect Hitachi-GE to:

- take account of all relevant risks in all modes of plant operation, *i.e.* start-up and shutdown;
- consider the appropriateness of their current approach to claiming the adoption of generic guidance reduces risks SFAIRP;
- demonstrate UK ABWR conforms to relevant good practice, for example, the requirements of the Approved Code of Practice (ACoP) [6] for DSEAR, have been considered;
- identify areas of the design where relevant good practice has not been met and provide a demonstration to justify gross disproportion if additional measures to reduce the risk are not taken;
- document the information in a clear and logical manner in a location in the hierarchy of UK ABWR safety case documentation, which is commensurate with the hazard and the basis for risk management, as informed by the UK ABWR safety case.

ONR's assessment of the response(s) to this RO will be undertaken jointly by reactor chemistry and internal hazards, as a minimum. There may be other disciplines, for example mechanical engineering, where this RO may act as an input. ONR therefore expects a similar, coordinated approach, to be adopted by Hitachi-GE.

GLOSSARY

In the context of this RO, 'process' and 'plant' are defined as follows:

Process: The structures, systems and components which provide primary containment and which when taken together comprise the nuclear reactor and associated systems.

Plant: The totality of structures on the facility which are external to the process, but do not form part of the primary containment.

References:

[1] 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

[2] UK ABWR GDA – Countermeasures Against Radiolytic Gases (Response to RQ-ABWR-0080), GA91-9201-0003-00093, Revision 0, May 2014, Hitachi-GE.

[3] UK ABWR GDA - Topic Report on Methodology of Radiolysis Gases (Including JANTI Guidelines), GA91-9201-0001-00106, Revision 0, December 2014, Hitachi-GE.

[4] UK ABWR GDA - Off-gas System Basis of Safety Case, GA9109201-0002-00054, revision 1, December 2014, Hitachi-GE.

[5] The Dangerous Substances and Explosive Atmospheres Regulations (DSEAR) 2002, HSE, <http://www.hse.gov.uk/fireandexplosion/dsear.htm>

[6] The Dangerous Substances and Explosive Atmospheres Regulations (DSEAR) 2002, Approved Code of Practice and Guidance, Revision 2, September 2013, HSE, <http://www.hse.gov.uk/pubns/books/l138.htm>

Regulatory Observation Actions

RO-ABWR-0044.A1 – Hitachi-GE are required to identify all potential areas in the UK ABWR design (within the process and plant) which may be susceptible to the formation of flammable atmospheres, either directly or following the accumulation of radiolysis gases.

The response to this Action is concerned with the generation, accumulation and possible enrichment of radiolysis gases within the process and plant. See the glossary of terms above.

The response to this Action should seek to articulate Hitachi-GE's understanding of the role standards and guidance play in claiming the UK ABWR design reduces risks SFAIRP.

In responding to this Action if Hitachi-GE choose to use generic design guidance from relevant standards ONR expect Hitachi-GE to identify specifically, for UK ABWR, all vulnerable areas of the facility identified from the application of that guidance. To be able to demonstrate all potentially vulnerable areas have been considered, ONR expects Hitachi-GE to justify the appropriateness of generic guidelines, when considering the requirements of DSEAR and UK health and safety legislation. Some generic design standards may screen out some systems from further assessment, which may need to be considered in the UK for Hitachi-GE to be able to demonstrate UK ABWR is capable of meeting UK legal requirements.

ONR expects Hitachi-GE to take account of relevant Worldwide OPEX in responding to this Action.

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-0044.A2 – Hitachi-GE are required to undertake a consequence analysis based on a worst case unmitigated scenario to evaluate the impact of an explosion (including consequential events) on structures, systems and components.

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-0044.A3 – Hitachi-GE are required to identify and implement all reasonably practicable measures which have been taken to address the vulnerable areas in the UK ABWR design (within the process and plant)

identified under Action 1.

Based upon the response to Action 1, Hitachi-GE should provide an explanation of the measures, which have been taken specifically for the UK ABWR design to: eliminate, reduce or mitigate the risks of radiolysis gas accumulation. The response should provide a demonstration that risks have been reduced SFAIRP.

The response should clearly identify all of the countermeasures taken and clearly explain the safety function and/or operational purpose of the vulnerable components/parts of the process identified, together with a description of the consequences of their failure. For areas of plant/components, which may have been modified, ONR need to understand why it is not reasonably practicable to eliminate them from the design.

ONR expects Hitachi-GE to take account of relevant Worldwide OPEX in responding to this Action.

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-0044.A4 – Hitachi-GE are required to appropriately describe and document, in the UK ABWR safety case, the risks and hazard presented by radiolysis gases under normal operation.

Based upon the response(s) provided to Actions 1-3, Hitachi-GE should consider their approach to documenting and presenting the claims, arguments and evidence, which taken together, demonstrate the UK ABWR has been designed to safely manage radiolysis gases generated under normal operations.

ONR expects the UK ABWR safety case to present a clear and logical description of the hazard, commensurate with the level of risk posed.

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: