REGULATORY OBSERVATION

REGULATOR TO COMPLETE

RO unique no.:	RO-ABWR-0075
Date sent:	22 November 2016
Acknowledgement required by:	16 December 2016
Agreement of Resolution Plan Required by:	20 January 2017
Resolution of Regulatory Observation required by:	To be determined by Hitachi-GE Resolution Plan
TRIM Ref:	2016/352419
Related RQ / RO No. and TRIM Ref. (if any)**:**	RQ-ABWR-1048 (2016/341096) RO-ABWR-0015 (2014/253182) RO-ABWR-0016 (2014/253045) RO-ABWR-0017 (2014/253119) RO-ABWR-0018 (2014/252937) RO-ABWR-0051 (2015/167687) RO-ABWR-0052 (2015/167963) RO-ABWR-0064 (2015/390811) RO-ABWR-0065 (2015/390786)
Observation title:	Robust demonstration that the design of the UK ABWR HVAC system has been adequately conceived and reduces risks SFAIRP
Technical area(s) 11. Mechanical Engineering 1. Internal Hazards 3. External Hazards 4. PSA 5. Fault Studies 6. Control & Instrumentation 10. Radiation Protection & (Level 3 PSA) 19. Conventional/Fire Safety 13. Human Factors	**Related technical area(s)** 11. Mechanical Engineering 1. Internal Hazards 3. External Hazards 4. PSA 5. Fault Studies 6. Control & Instrumentation 10. Radiation Protection & (Level 3 PSA) 19. Conventional/Fire Safety 13. Human Factors

Section 1: Regulatory Observation

BACKGROUND

ONR has carried out a multi-disciplinary assessment of Hitachi-GEs Basis of Safety Case (BoSC) for the UK ABWR Heating, Ventilation and Air Conditioning (HVAC) system (Doc ref: GA91-9201-0002-00041 Revision 2). ONRs assessment has revealed a number of gaps between Hitachi-GE's submission and regulatory expectations. The observations and actions contained within this RO identify areas where Hitachi-GE need to provide additional evidence in order to demonstrate that the design of the UK ABWR HVAC system is fit for purpose and reduces risks So Far As is Reasonably Practicable (SFAIRP).

OBSERVATIONS AND EXPECTATIONS

Observation 1: Safety Categorisation and Classification

It is important that Structures, Systems and Components (SSC), including software for control and instrumentation, are categorised and classified on the basis of their safety significance. Interfaces between SSC of different category and class shall be designed in such a way to ensure that any failure in a lower category and class item will not adversely impact an SSC of a higher category and class. In addition, auxiliary services that support components of a system important to safety should be considered part of that system and should be categorised and classified accordingly.

The HVAC BoSC does not provide an adequate level of assurance that the interfaces between SSCs have been designed such that failure in a lower class item will not propagate to higher safety class items and

jeopardise the delivery of the corresponding safety functions. It is an expectation that the following two principles have been applied throughout the design phase and where a deviation exists a robust justification is provided which demonstrates that risk has been reduced SFAIRP;

1. SSC dependent on HVAC are supported by the same class of HVAC system;
2. Mechanical SSC comprise of the same class of piece part components.

A single example of where regulatory expectations have not been met is provided below;

- The Main Control Room HVAC is designed to maintain a habitable environment and to ensure the operability of Class 1 and 2 nuclear safety components. This Class 1 HVAC system contains a Class 3 humidifier unit and humidity management is important to C&I reliability.

See action 1 in section 2.

Observation 2: Cliff edge effects

The BoSC does not adequately demonstrate that cliff-edge effects have been considered (in accordance with ONRs SAP EHA.7) at the HVAC concept design phase.
A single example of where the BoSC should make a robust, evidence based demonstration that cliff edge effects have been considered is where a seismic categorisation is claimed. A robust safety case will identify the margins beyond the design basis to the point where safety functions would no longer be achieved and in this case link this to the seismic categorisation. **See action 2 in section 2.**

Observation 3: Interfaces and heat management

The HVAC system design and its interfaces with other SSC is not adequately scoped. In general the BoSC describes a HVAC system to comprise of fans, heating and cooling coils and in some cases filters and/or dampers. There is no detail to substantiate how the cooling and heat transfer functions are delivered.
One of the key functions of the HVAC system is claimed as the "removal of heat from the atmosphere within each building as it is generated by equipment such as electric panels, mechanical facilities and piping with high temperature etc".

For the above claim to be met and for the associated cooling system design requirements to be generated by the responsible designer a fundamental input is required. Accurate calculations for the total sum of heat generated within each building to be removed. The concept design for the cooling system can then be developed. There is no evidence presented to provide the assurance that the heat loads within each building are understood and that the cooling system has been designed accordingly.
See action 3 in section 2.

Observation 4: Design for reliability

In accordance with ONRs SAP EDR.2, Redundancy, diversity and segregation should be incorporated as appropriate within the designs of SSC.
There is no evidence that segregation has been considered by the responsible designer to ensure failure independence. It is an expectation that segregation requirements are specified at the concept design stage as they have the potential to impact on the building layout. If the need for segregation is deemed unnecessary then this must be justified with evidence.
The only diversity claim made is that "the back-up building forms part of the diverse measures to deliver fundamental safety functions". With the limited amount of detail here I conclude this statement to be more consistent with the principal of redundancy. Examples of diversity are different operating conditions, different working principles, different design teams, different sizes of equipment, different manufacturers, different components, and types of equipment that use different physical methods.
A single example of where regulatory expectations have not been met is provided below;

- There are a number of local cooling units for different Divisions. No evidence is available to provide the assurance that these local cooling units do not possess the potential for common cause failures due to lack of diversity.

See action 4 in section 2.

Observation 5: Indoor environmental conditions

The BoSC sets out the environmental limits and conditions for each building area which is supported by a HVAC system e.g. minimum and maximum temperature and maximum Relative Humidity (RH) levels. The design basis for these values is not substantiated by arguments or evidence.
This falls short of ONRs regulatory expectations for a concept design and does not provide the basis for a

robust safety case. Where environmental targets and limits are claimed, these should be substantiated with a robust safety justification which details;

1. the underpinning design basis rationale for the values to include analysis of all reactor operating states;
2. safe operating margins outside of the environmental targets and limits;
3. the consequence on dependent SSC of deviation from the environmental targets and limits.

The concept safety case should present claims and arguments detailing how the engineered properties of the system architecture will ensure continued safe operation in all normal and design basis accident conditions. **See action 5 in section 2.**

Observation 6: Hazard propagation

The HVAC has the potential to propagate hazard effects to other areas. How the HVAC protects personnel and equipment against specific risks from inside and outside the buildings has not been justified in the BoSC. An example of propagating hazards may be steam or water migrating internally to moisture sensitive areas or gases from an external fire being drawn into inhabited areas. **See action 6 in section 2.**

Observation 7: Class 3 Humidifier

As previously discussed Class 1 HVAC systems contain Class 3 humidifier units, meaning these Class 3 units contribute to a categorised safety function. The purpose of a humidifier is to maintain a controlled humidity environment, particularly in winter months. The BoSC does not provide a robust justification for the classification of the humidifier units nor an impact assessment for loss of humidifier functionality on nuclear safety systems. **See action 7 in section 2.**

Observation 8: Step 4 evidence requirements

Throughout the BoSC very specific performance figures are quoted without providing any link to evidence to substantiate the design basis.
This presents a shortfall against expectations for a concept design and does not provide the basis for a robust safety case. The derivation of all performance figures claimed in safety documentation must be justified using evidence e.g. underpinning design calculations. Before any HVAC system can be designed at the concept phase a summation of individual heat loads from dependant systems must be calculated. A broad range of calculations will need to be made for each individual HVAC system taking into account the full range of external environmental conditions and localised conditions expected during different reactor operational, shut down and accident states. Only once the load calculations are made can performance requirements be ascertained, design margins be applied and the system be sized.
The current lack of evidence underpinning the design calculations at the concept design phase prompts the following concerns;

1. The specific performance figures will not be able to be met during detailed design and without the rationale for their derivation the equipment designer cannot understand their criticality and permissible tolerances. This may lead to a redesign from 1st principles.
2. The specific performance figures have not been developed based on accurate heat load calculations, this may result in;
    a) a re-design from 1st principles;
    b) an oversized HVAC system (frequent starting and stopping, short cycling, reduction in reliability);
    c) an undersized system design, larger units required, inadequate building layout to house the HVAC units.

A single example of where very specific performance figures have been quoted without any evidence to substantiate the design basis is provided below;
The BBEE/Z HVAC has a fan air flow rate of 15100 m^3/h, a fan static pressure of ≥ 0.980 kPa and a cooling coil capacity of 183.8 kW per unit. **See action 8 in section 2.**

Observation 9: Availability of HVAC for decommissioning

Safety Property Claim ME 7 states: “The HVAC SSCs are capable to deliver their safety functions under the

associated operational and environmental conditions throughout their operational life". The useful operational life of the UK ABWR HVAC is claimed as being 60 years which is the same as the planned operational life of the plant. The HVAC safety documentation does not consider the requirement for HVAC systems to support Post Operational Clean Out (POCO) or decommissioning phases of the facility lifecycle. In accordance with ONR SAP DC.1 - Decommissioning should be taken into account during the planning and design of a new facility. **See action 9 in section 2.**

Observation 10: Qualification

Section SPC ME 7, Qualification.
Qualification provisions have not been adequately defined and do not align with regulatory expectations as set out in ONRs SAP EQU (Equipment Qualification) and Technical Assessment Guide NS-TAST-GD-094.
See action 10 in section 2.

Observation 11: Filter units

Page 247 illustrates the configuration of safe change filter units forming a "U Shape". This should not be seen as an optimal configuration as it potentially provides an exposure to radiation from almost a full 360 degrees and leaves challenges to space for access, egress. **See action 11 in section 2.**

Observation 12: Local Extract Ventilation (LEV)

HVAC systems are frequently designed with the facility for LEV. The opportunity to provide LEV has not been explored in the current design of HVAC for the UK ABWR. The provision of LEV may in some instances provide a diverse means of ventilation to ensure that the hierarchy of risk control measures can be appropriately applied. **See action 12 in section 2.**

Observation 13: Arrangements to transition between HVAC and SGTS

The Stand-by Gas Treatment System (SGTS) is designed to operate in place of the HVAC following the detection of high radiation/contamination levels. The SGTS transition is automatic apart from the Dry Well operation which is manual. It does not meet with ONRs expectations for a safety system to be manually operated due to human intervention reliability concerns. **See action 13 in section 2.**

Section 2: Regulatory Observation Actions

RO-ABWR-0075.A1 - Safety Categorisation and Classification
ONR expect Hitachi-GE to;

- identify all instances where the following two conditions are applicable;
  - SSC dependent on HVAC are not supported by the same class of HVAC system;
  - Mechanical SSC of a higher category and class comprise of lower category and class piece part components
- provide the design justification evidence to demonstrate that where either one of the above two conditions are applicable, the design process adopted has robustly assessed that risk has been reduced SFAIRP.

RO-ABWR-0075.A2 – Cliff edge effects

Action 2: ONR expect Hitachi-GE to;

- Provide evidence demonstrating that cliff-edge effects have been considered at the concept design phase, in accordance with ONR SAPs, for all credible internal and external hazards against each of the individual HVAC systems;

RO-ABWR-0075.A3 – Interfaces and heat management

For each individual HVAC system ONR expect Hitachi-GE to provide a detailed design description for its related cooling system to include, but not limited to;

- categorisation and classification (in accordance with Action 1);
- design for reliability considerations in accordance with ONR SAP EDR.2 (Redundancy, diversity and segregation);
- interfaces with other SSCs e.g. heat exchangers;
- the heat load calculations for each building and evidence that the corresponding cooling system is

adequately designed to manage the maximum heat output from that building.

RO-ABWR-0075.A4 – Design for reliability

ONR expect Hitachi-GE to provide detailed evidence to demonstrate how it has considered the requirements of segregation and diversity during the concept design phase for each individual HVAC system. Its demonstration must provide assurance through evidence that the required level of reliability for their intended safety function has been achieved and that risk has been reduced SFAIRP.

RO-ABWR-0075.A5 – Indoor environmental conditions

ONR expects Hitachi-GE to provide a detailed design justification, supported by evidence, to address the following observations;

- what is the nuclear and conventional safety impact on all HVAC dependent SSC, including C&I and electrical, if the 90% maximum RH is exceeded;
- what are the design basis safe operating margins, over time, if the 90% RH levels are exceed for all HVAC dependent SSC;
- what are the HVAC system design properties and associated safety systems that ensure a RH level of 90% cannot be exceeded;
- where high humidity warm air is cooled condensate is formed. How have the risks to SSC, including C&I and electrical, from condensate been reduced SFAIRP;
- design basis faults will impact the HVAC systems. One example is a Clean Up Water system failure generating a substantial volume of steam. How have the risks to HVAC from design basis faults been reduced SFAIRP;
- what are the safe operational temperature (high and low) and moisture limits, to include design margins, for HVAC dependent SSC, including C&I and electrical.

RO-ABWR-0075.A6 – Hazard propagation

ONR expects Hitachi-GE to explain in detail how it has considered the propagation of all credible hazards during the HVAC concept design phase and provide evidence to demonstrate that risks have been reduced SFAIRP.

RO-ABWR-0075.A7 – Class 3 humidifier

In accordance with action 1 ONR expects Hitachi-GE to provide the design basis substantiation for the categorisation and classification of its humidifier units. In addition ONR expects Hitachi-GE to provide, through evidence, an impact assessment following loss of humidifier functionality on all other SSCs (C&I, electrical, Mechanical etc).

RO-ABWR-0075.A8 – Step 4 evidence requirements

For the purposes of RO closure it is an expectation that the underpinning concept design calculations will be made available for sampling. ONR expect Hitachi-GE to provide evidence to substantiate all system performance figures quoted within the BoSC during GDA Step 4.

RO-ABWR-0075.A9 – Availability of HVAC for decommissioning

Substantiated with evidence, ONR expect Hitachi-GE to explain;

- the requirement to be placed upon the HVAC systems for each individual area of the facility for POCO and decommissioning activities;
- how the design process for each HVAC system considered the decommissioning phase of the facility;
- design changes or modifications to the baseline deign to facilitate decommissioning activities;
- the overall design life of each HVAC system and its qualification strategy where it is required for decommissioning.

RO-ABWR-0075.A10 – Qualification

ONR expects Hitachi-GE to review the qualification requirements, as set out in ONRs SAP and TAG, and align its safety case to meet with these requirements.

RO-ABWR-0075.A11 – Filter units

ONR expects Hitachi-GE to provide its design justification for the configuration of its filter banks. This should provide evidence that the design has been optioneered to reduce risk SFAIRP considering;

- Access and egress, installation, commissioning, examination, inspection, maintenance and test;
- Radiation protection and worker dose.

RO-ABWR-0075.A12 – Local Exhaust Ventilation

ONR expect Hitachi-GE to provide its design justification for the exclusion of LEV in its concept design for the UK ABWR.

RO-ABWR-0075.A13 – Arrangements to transition between HVAC and SGTS

ONR expects Hitachi-GE to provide a robust safety justification for its methodology to transition from HVAC operation to SGTS.

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:	