

REGULATORY OBSERVATION

REGULATOR TO COMPLETE

RO unique no.:	RO-UKHPR1000-0039
Revision:	0
Date sent:	07/04/20
Acknowledgement required by:	30/04/20
Agreement of Resolution Plan Required by:	09/07/20
CM9 Ref:	2020/106859
Related RQ / RO No. and CM9 Ref: (if any):	RO-UKHPR1000-0002 (2018/43924) RO-UKHPR1000-0004 (2018/255957) RO-UKHPR1000-0012 (2019/135431) RO-UKHPR1000-0023 (2019/297976) RQ-UKHPR1000-0556 (2019/340000) RQ-UKHPR1000-0386 (2019/302561)
Observation title:	Performance Analysis of UK HPR1000 Heating Ventilation and Air Conditioning Systems
Lead technical topic:	Related technical topic(s):
14. Mechanical Engineering	3. Control & Instrumentation 6. Cross Cutting 7. Electrical Engineering 8. External Hazards 9. Fault Studies 11. Human Factors 15. Probabilistic Safety Analysis 19. Severe Accident Analysis

Regulatory Observation

Background

The UK HPR1000 heating, ventilation and air conditioning (HVAC) systems plays a key role in delivering safe operation of the UK HPR1000 plant.

The UK HPR1000 HVAC systems:

- Maintain UK HPR1000 environmental conditions within:
 - The engineering equipment's qualified limits of temperature and humidity; and
 - Appropriate limits which deliver reliable human performance (i.e. room habitability etc.)
- Controls the spread of contamination; and
- Supports other UK HPR1000 safety systems to deliver against their safety demands*.

During Generic Design Assessment (GDA), the Requesting Party (RP) should demonstrate the UK HPR1000 HVAC systems can deliver against the safety demands placed upon them. The RP has submitted a number of related UK HPR1000 HVAC submissions (Ref. 1) and its references. These submissions have led ONR to question the adequacy of:

- The robustness of the HVAC systems' environmental modelling against a background of differences in extreme weather events (RO-UKHPR1000-0002) [Ref. 7]. The current modelling (RQ-UKHPR1000-0556) (Ref. 7) uses a basic rather than intermediate approach. The basic approach may be difficult to quality assure and may not fully support the basis of the safety argument(s) being made.

- Identification of all of the safety demands associated with the HVAC systems.
- The approach to environmental modelling, which may not adequately address all relevant scenarios. For example, environmental conditions should not challenge the qualified limits of operation.

The adequacy of the environmental modelling, against a selection of bounding plant transients (and documented set of safety demands), is the focus of this mechanical engineering regulatory observation (RO).

The purposes of this mechanical engineering RO is for the RP to:

- Develop, and agree with ONR, a strategy to adequately model a sample of risk important UK HPR1000 HVAC systems, rooms and their contents during a selection of plant transients. The strategy should justify the samples chosen.
- Adopt a graded approach to the analysis; the extensive use of Computational Fluid Dynamics (CFD) modelling to address this RO may not be proportionate.
- Implement the strategy to demonstrate the sample of UK HPR1000 HVAC systems can adequately deliver the operational and safety demands placed upon them (as detailed within their safety functions and / or design provisions). This specifically relates to the environmental demands on a sample of HVAC systems.
- Confirm via independent verification that the UK HPR1000 HVAC systems environmental modelling approach is satisfactory.
- Identify whether there are any gaps in the design of the UK HPR1000 HVAC systems.
- Undertake an ALARP study against any gaps identified.

Relevant Legislation, Standards and Guidance

The following relate to the design of the UK HPR1000 HVAC system:

- ONR Safety Assessment Principles <http://www.onr.org.uk/saps/saps2014.pdf> (Ref. 2)
- ECS – Safety classification and standards
- EQU – Equipment qualification
- FA – Fault analysis
- EHA – External and internal hazards
- AV – Assurance of validity of data and models
- ESS – Safety systems
- EHF – Human Factors
- NS-TAST-GD-022 Revision 5 – Ventilation
http://www.onr.org.uk/operational/tech_asst_guides/index.htm. (Ref. 3)
- NS-TAST-GD-005 Revision 10 - Guidance on the Demonstration of ALARP (As Low As Reasonably Practicable) (Ref. 4)
http://www.onr.org.uk/operational/tech_asst_guides/index.htm. (Ref.4)
- ES_0_1738_1_Issue 1, Ventilation Systems for Radiological Facilities Design Guide, May 2015 (Ref. 5)
- CIBSE guidance (Guide B) <https://www.cibse.org/knowledge/cibse-publications/cibse-guides>. (Ref. 6)

Regulatory Expectations

In responding to this RO ONR expects the RP to:

- Develop and agree a strategy to analyse the performance of the UK HPR1000 HVAC systems. This strategy should seek to define:
 - The identification of a suitable method(s) to analyse the UK HPR1000 HVAC systems.
 - How the design of UK HPR1000 HVAC systems will be analysed (including modelling of the different room types). This should include the following design inputs:
 - The safety functions / design provisions;
 - The safety classifications;
 - The qualified limits and conditions of safe operation of the associated equipment;
 - Selection of bounding plant transients. For example station blackout (SBO) and extreme weather; and
 - Approach to sensitivity analysis
 - The approach to respond to any identified gaps (from both an engineering and safety case perspective).
- Implement the strategy within Step 4 of the GDA.
- Undertake independent verification of the UK HPR1000 HVAC performance analysis.

ONR expects the RP to adequately coordinate the HVAC systems analysis with the related disciplines outlined below. Examples include consideration of:

- Thermal loading and qualification of the related electrical, control and instrumentation (EC&I) equipment (EC&I disciplines).
- A bounding selection of plant transients against which the functional capability of sample HVAC systems will be analysed (Safety Analysis disciplines).
- Extreme weather events and combinations, including demonstrating resilience to beyond design basis events (External Hazards).
- Impact on human performance during plant transients (Human Factors).
- Related regulatory observations / queries (Ref. 7)
 - RO-UKHPR1000-0002 Demonstration that the UK HPR1000 Design is Suitably Aligned with the Generic Site Envelope (External Hazards). For some external hazards (i.e. extreme high air temperature), the RP has identified different values for UK HPR1000, to those specified for the Reference Design (Fangchenggang Unit 3, FCG-3). These differences could impact the design of UK HPR1000 HVAC systems and the extent of analysis performed.
 - RO-UKHPR1000-0004 Development of a Suitable and Sufficient Safety Case (Cross Cutting)
 - RO-UKHPR1000-0012 Identification and Application of Relevant Good Practice Applicable to Mechanical Engineering for the UK HPR1000 Design (Mechanical Engineering).
 - RO-UKHPR1000-0023 Demonstration of Diverse Protection for Frequent Faults (Fault Studies). This should capture any diversity requirements necessary for UK HPR1000 HVAC systems, which support a main line of protection for frequent faults. This may have important

implications for the design of the UK HPR1000 HVAC systems and the extent of analysis performed.

- RQ-UKHPR1000-0556 UK HPR1000 HVAC Analysis (Mechanical Engineering); and
- RQ-UKHPR1000-0386 Consequence Analysis of HVAC Failure Supplying Safety Important Control and Monitoring Locations (Human Factors).

Glossary

*In this RO the terms:

- “*environmental modelling*” refers to temperature, humidity and enthalpy.
- “*safety demands*” refer to safety functional and / or design provisions (including limits and conditions of safe operation).

References

1. UK HPR1000 - HPR/GDA/PCSR/0010 - PCSR - Chapter 10 - Auxiliary Systems - Rev 001 - 10 January 2020 CM9 2020/13656.
2. ONR Safety Assessment Principles <http://www.onr.org.uk/saps/saps2014.pdf>.
3. NS-TAST-GD-022 Revision 5 – Ventilation.
http://www.onr.org.uk/operational/tech_asst_guides/index.htm
4. NS-TAST-GD-005 Revision 10 - Guidance on the Demonstration of ALARP (As Low As Reasonably Practicable) (Ref.4).
5. ES_0_1738_1_Issue 1, Ventilation Systems for Radiological Facilities Design Guide, May 2015.
6. CIBSE guidance (Guide B) <https://www.cibse.org/knowledge/cibse-publications/cibse-guides>.
7. Regulatory Queries (RQs) and Regulatory Observations (RO's):
 - RO-UKHPR1000-0002 Demonstration that the UK HPR1000 Design is Suitably Aligned with the Generic Site Envelope CM9 2018/43924.
 - RO-UKHPR1000-0004 Development of a Suitable and Sufficient Safety Case CM9 2018/255957.
 - RO-UKHPR1000-0012 Identification and Application of Relevant Good Practice Applicable to Mechanical Engineering for the UK HPR1000 Design CM9 2019/135431.
 - RO-UKHPR1000-0023 Demonstration of Diverse Protection for Frequent Faults CM9 2019/297976.
 - RQ-UKHPR1000-0556 UK HPR1000 HVAC Analysis CM9 2019/340000.
 - RQ-UKHPR1000-0386 Consequence Analysis of HVAC Failure Supplying Safety Important Control and Monitoring Locations CM9 2019/302561.

Regulatory Observation Actions

RO-UKHPR1000-0039.A1 – Develop an Appropriate UK HPR1000 HVAC Environmental Modelling and Analysis Strategy

In response to this Regulatory Observation Action (ROA), the RP should:

- Develop a strategy to analyse a sample of UK HPR1000 HVAC systems. The strategy should seek to:
 - Identify a suitable method(s) to model the HVAC systems. For example, a software modelling package with appropriate certification.
 - Describe how the UK HPR1000 HVAC systems performance will be analysed, which should:
 - Identify and justify which UK HPR1000 HVAC systems, rooms and their contents will be considered.
 - Describe the modelling approach for the different systems / and or room types.
 - Identify and explain the related UK HPR1000 safety demands (associated input data) against which the performance analysis will be undertaken. This should include the:
 - Safety functions / design provisions;
 - Safety classification of equipment delivering the safety function / design provisions;
 - Qualified limits and conditions of safe operation of the associated equipment;
 - Selection of bounding plant transients against which the analysis will be undertaken; and
 - Approach to sensitivity analysis.
 - Describe how the analysis output will be used (including ALARP considerations and appropriately documenting the work in the generic safety case).

The response to this ROA may be combined with any other ROA under this RO, if deemed appropriate.

Resolution required by 'to be determined by General Nuclear System Resolution Plan'

RO-UKHPR1000-0039.A2 – Model and Analyse the UK HPR1000 Heating Ventilation and Air Conditioning Systems

Based on the outcome of the work to respond to ROA 1 above, in response to this ROA, the RP should:

- Using the method identified in ROA 1, analyse and confirm the performance (or otherwise) of the UK HPR1000 HVAC systems against the safety demands.
- Detail and justify any assumptions within the analysis undertaken, including undertaking a suitable sensitivity analysis.
- Undertake an independent verification of the analysis.
- Confirm or otherwise, using the results of the analysis, the level of agreement between the commercial software package and the RP's extant analysis.
- Identify any shortfalls and gaps in the HVAC systems performance against their safety demands.

The response to this ROA may be combined with any other ROA under this RO, if deemed appropriate.

Resolution required by 'to be determined by General Nuclear System Resolution Plan'

RO-UKHPR1000-0039.A3 – Undertake a ALARP Analysis for UK HPR1000 HVAC Systems

Based on the outcome of the work to respond to ROA 1 and 2 above, in response to this ROA, the RP should:

- Identify any other impacted UK HPR1000 safety systems, ALARP considerations of these impacted systems is outside the scope of the ROA.

- Undertake an optioneering study to identify appropriate solutions to address shortfalls and / or gaps in the UK HPR1000 HVAC systems
- Explain and justify whether any options have been identified as being reasonably practicable to implement.
- Explain which, if any, UK HPR1000 HVAC systems may require modifying.
- Explain how those modifications could be implemented, and how the generic safety case will be updated.

The response to this ROA may be combined with any other ROA under this RO, if deemed appropriate.

Resolution required by '*to be determined by General Nuclear System Resolution Plan*'

REQUESTING PARTY TO COMPLETE	
Actual Acknowledgement date:	
RP stated Resolution Plan agreement date:	