REGULATORY OBSERVATION

REGULATOR TO COMPLETE

RO unique no.:	RO-UKHPR1000-0026
Revision:	1
Date sent:	09/10/20
Acknowledgement required by:	16/10/20
Agreement of Resolution Plan Required by:	06/11/20
CM9 Ref:	2020/298271
Related RQ / RO No. and CM9 Ref: (if any)**:**	RQ 390 – Source Term ALARP Demonstration (2019/252788), 995 – Corrosion Product Analysis (2020/233634) RO-UKHPR1000-0026 Rev 0 - 2019/312783
Observation title:	Demonstration that radioactivity has been reduced So Far As Is Reasonably Practicable (SFAIRP)
Lead technical topic: 1. Chemistry	**Related technical topic(s):** 9. Fault Studies 10. Fuel & Core 14. Mechanical Engineering 16. Radiological Protection 17. RadWaste, Decommissioning & Spent Fuel Management 20. Structural Integrity 21. Environmental

Regulatory Observation

Background

The radioactivity present in the primary circuit of a Pressurised Water Reactor (PWR), and other systems connected to the primary circuit, is an important contributor to Operator Radiation Exposure (ORE), routine radioactive wastes and acts as a potential source term during accident scenarios. The designers and operator of a PWR can influence the concentrations and behaviour of radioactivity by exercising adequate control over the operating chemistry, minimising impurity levels and by choices made during plant design and operations.

For the Generic Design Assessment (GDA) of UK HPR1000, the Requesting Party (RP) has recognised the importance of the control of radioactivity on nuclear safety, and provided claims and arguments across multiple topics to this effect. Additional technical submissions made throughout the Step support this approach. For example, two Chemistry related topic reports, that cover power operation chemistry [1], and the chemistry of start-up and shutdown, [2], both recognise the need to justify the radiochemistry of the primary circuit. As well as these documents, ONR has continued to receive and assess the RP's suite of supporting documentation which defines and justifies the radiological source term(s) for UK HPR1000 [3].

However, to date, it is not clear what evidence the RP will provide to support these claims and arguments. While the RP has indicated that it plans to address this gap in future documentation, the scope of what is proposed or the timescales for doing so remain unclear. It is also unclear how the safety case will be integrated to ensure that a holistic justification is provided in terms of demonstrating that radioactivity has been reduced So Far As Is Reasonably Practicable, (SFAIRP). In particular ONR expects that the RP should provide an adequate demonstration of how radioactivity is generated and transported in UK HPR1000, provide information on the nature and quantity of all radiochemical species, and demonstrate that radioactivity has been reduced SFAIRP.

ONR have already raised RO-UKHPR1000-0015, Demonstration that Risks Associated with Fuel Deposits are Reduced so far as is Reasonably Practicable (SFAIRP), which is closely related to this RO but deals

exclusively with the safety impacts of fuel deposits which can be wider than the generation of radioactivity [4].

This Regulatory Observation (RO) has therefore been raised to:

- Explain ONR's regulatory expectations;
- Ensure the RP provides a suitable safety case for the risks presented by the radioactivity expected to be present in the primary circuit and other connected systems of the UK HPR1000;
- Obtain confidence that adequate evidence will be provided by the RP to support the claims and arguments made in the UK HPR1000 generic safety case; and
- Assist ONR's judgement of whether a robust demonstration that radioactivity within UK HPR1000 will be reduced SFAIRP.

Relevant Legislation, Standards and Guidance

ONR's Safety Assessment Principles (SAPs) [5] provide a framework for making consistent regulatory judgements on the safety of activities. Of direct relevance to this RO is SAP SC.4:

The regulatory assessment of safety cases	Safety case characteristics	SC.4
A safety case should be accurate, objective and demonstrably complete for its intended purpose.		

Associated paragraphs 100, 101 and 102 explain this principle further.

The chemistry section of ONR's Safety Assessment Principles (SAPs) [5] contains SAP ECH.1:

Engineering principles: chemistry	Safety cases	ECH.1
Safety cases should, by applying a systematic process, address all chemistry effects important to safety.		

Paragraph 511 of Reference 5 then goes onto state:

"The safety case should identify and analyse how chemistry can impact safety during normal operations and in fault and accident conditions, and demonstrate how the chemistry will be controlled."

Paragraph 569, supporting SAP EHT.1, is also relevant and states:

"*The design, construction and operation of the facility and the choice of heat transfer fluid should minimise the amount of radioactive material in the fluid. Provision should be made to monitor, control and remove any significant build-up of radioactive material from the heat transport fluid and associated containment.*"

This is further supported in ONR's Technical Assessment Guides (TAGs), including *Chemistry of Operating Civil Nuclear Reactors* [6].

Regulatory Expectations

Overall, ONR expect the claims and arguments presented in the PCSR and supporting references to be adequately substantiated by suitable and sufficient evidence. ONR would therefore expect the safety case for UK HPR1000 to:

- Quantify (estimate) and characterise (i.e. chemical/physical characteristics) of all radioactive species present in the primary circuit and other connected systems of the UKHPR1000, during normal operational states.
- Adequately justify the estimates for radioactivity in UK HPR1000. The information provided should include a suitable amount of robust supporting evidence and be demonstrated to be appropriate for the UK HPR1000 design and consistent with the extant generic safety case.
- Substantiate the systems, controls and measures that will be used to minimise and remove the radionuclides identified, including identifying appropriate limits and conditions necessary in the

interests of safety.
- Demonstrate that all reasonably practicable measures have been taken to reduce radioactivity in UK HPR1000 SFAIRP.

Therefore in responding to this RO, ONR expects the RP to:

- Demonstrate how the safety case will cover those aspects described above;
- Provide an explicit demonstration that radioactivity in UK HPR1000 will be reduced SFAIRP;
- Identify any associated controls, limits and conditions necessary to ensure this is achieved; and
- Substantiate that the plant design and engineering is adequate to reduce radioactivity SFAIRP.

References

[1] *Topic Report of Power Operation Chemistry,* Rev B, GHX00100104DCHS03 GN, April 2019.
[2] *Topic Report on start-up and shutdown chemistry,* Rev B, GHX00100105DCHS03GN, April 2019.
[3] *Normal Operation Source Term Strategy Report*, GHX90300002DNFP03GN, Rev B, CGN, June 2018. CM9 Ref. 2018/215200.
[4] RO-UKHPR1000-0015, Demonstration that Risks Associated with Fuel Deposits are Reduced so far as is Reasonably Practicable (SFAIRP). www.onr.org.uk/new-reactors/uk-hpr1000/ro-res-plan.htm
[5] *Safety Assessment Principles for Nuclear Facilities*, 2014 Edition, Revision 0, Office for Nuclear Regulation, 2014. www.onr.org.uk/saps/saps2014.pdf
[6] *Nuclear Safety Technical Assessment Guide, Chemistry of Operating Civil Nuclear Reactors*, NS-TAST-GD-088 Revision 2, Office for Nuclear Regulation, 2019.
www.onr.org.uk/operational/tech_asst_guides/index.htm

Glossary*

Normal operational states:
Including "normal operations" and "anticipated operational occurrences". For a nuclear power plant this includes: start-up, power operation, shutting down, shutdown, maintenance, testing and refuelling.

Regulatory Observation Actions

RO-UKHPR1000-0026.A1 – Produce a safety case route map for radioactivity in the UK HPR1000 design

In response to this Action the RP should:

- Provide a route map which identifies where information relating to the production, quantities, characterisation, distribution, behaviour and removal or clean-up of radioactivity in the UK HPR1000 safety case is documented.
- ONR expect this route map to explain how the safety case meets the regulatory expecations described in this RO, and any other matters considered relevent by the RP.
- The response should explain how the different technical topics interface and where the linkages, and differences may exist. In particular the on-going work in relation to defining the "source terms" for UK HPR1000 and resolving RO-UKHPR1000-0015 need to be considered in the response.
- The response should explain how and where any specific aspects of the UK HPR1000 design and operations which can impact on radioactivity are justified in the safety case, including:
    - The use of enriched boric acid and associated recycling
    - The design of the primary circuit hydrogen dosing system
    - The use of inerting applied to tanks and ullages
    - The operating chemistry regime, including the approach to start-up and shutdown chemistry
    - Material choices and treatments
    - The use of secondary neutron sources
    - Fuel cleanliness criteria
    - The dosing and clean-up systems and process
- Demonstrate that claims and arguments in the generic safety case are consistent between technical topics and with the underlying supporting evidence.
- Where in producing this route map the RP identifies gaps in the information presented as part of the safety case, additional information should be identified and a plan and timescales for its production and submission to ONR presented.

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-UKHPR1000-0026.A2 – Demonstrate that radioactivity in UK HPR1000 has been reduced SFAIRP

The overall intent for this Action is that the RP should identify the relevent nuclear safety risks associated with radioactivity in UK HPR1000 and provide a suitable and sufficient justification that they have been reduced so far as is reasonably practicable (SFAIRP).

In response to this Action the RP should:

- Identify the range of measures in place which eliminate, reduce and/or control the generation and accumulation of radiochemical species for UK HPR1000. An appropriate balance needs to be achieved and demonstrated. Information provided in response to this ROA should therefore include:
    - Evidence that operating practices which are necessary, expected, or can be applied for UK HPR1000 have been optimised in terms of reducing the generation and accumulation of radioactivity SFAIRP.
    - Evidence that the primary circuit operating chemistry for UK HPR1000 has been optimised to reduce the generation and accumulation of radioactivity SFAIRP.
    - Evidence those key materials choices and their surface treatments, have been considered from the perspective of reducing the generation and accumulation of radioactivity SFAIRP.
- Identify operational parameters and/or controls that may signifcantly impact the generation, transport and accumulation of radiochemical species in UK HPR1000 and explain the sensitivity to these.
- ONR recognise that some of the evidence and justification requested under this Action may exist in other parts of the generic safety case; in those instances the RP should clearly indicate this, including demonstrating its applicability to this Action, in particular the demonstration that it reduces risks SFAIRP.

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-UKHPR1000-0026.A3 – Demonstrate that the UK HPR1000 design is capable of minimising radioactivity in the primary circuit and connected systems

In response to this Action the RP should:

- Based on the response to A2, provide sufficient supporting evidence to demonstrate that the clean-up systems present in the UK HPR1000 have adequate capacity and capability to manage the levels of radioactivity predicted to be present in the plant.
- Identify the underpinning asumptions regarding the clean-up efficiencies of UK HPR1000 systems which are claimed to reduce, minimise, or eliminate radiochemical species, including a proportionate justifcation for these.
- The response should consider all operational states, as appropriate.
- The response should consider the primary circuit of UK HPR1000, but also other connected systems where radioactivity may be present, including:
    - CVCS and boron recycle equipment
    - Spent fuel pool
    - In-containment reactor water storage tank
    - Residual heat removal system
- ONR recognise that some of the evidence and justification requested under this Action may exist in other parts of the generic safety case; in those instances the RP should clearly indicate this, including demonstrating its applicability to this Action.

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-UKHPR1000-0026.A4 – Identify any controls necessary to ensure radioactivity in UK HPR1000 will be minimised

In response to this Action the RP should:

- Based on the responses to A2 and A3, identify the controls, including any limits and conditions, which are necessary to ensure radioactivity is reduced SFAIRP. Such controls need to be demonstrated to be consistent with the design, intended operations and generic safety case claims for UK HPR1000.

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-UKHPR1000-0026.A5 – Provide a plant specific quantification of activated corrosion products in the primary circuit of UK HPR1000 and all relevant associated systems

In response to this Action the RP should:

- Provide an adequate quantitative estimate, via calculation or other equivalent and suitable means, of the inventory and associated activities of corrosion products expected to be generated and transported in the primary circuit of the UK HPR1000. The estimate should take account of all relevant plant specific design features and anticipated operations. The estimate should cover all phases of normal, at-power operations, from start-up to shutdown.
- Estimate the quantities of activated corrosion products present in all relevant systems connected to the primary circuit, including the:
    - Spent Fuel Pool;
    - Chemical and Volume Control System (CVCS); and
    - In-containment Reactor Water Storage Tank (IRWST).
- Compare and contrast the quantitative estimate with the extant source term derived for activated corrosion products in the primary circuit and all relevant systems for UK HPR1000.

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:	