

 General Nuclear System	REGULATORY OBSERVATION RESOLUTION PLAN RO-UKHPR1000-0034	Rev.: 0	Page: 1 / 8
		GDA-REC-GNSL-006216	

REGULATORY OBSERVATION Resolution Plan


RO Unique No.:	RO-UKHPR1000-0034
RO Title:	Minimisation of flow accelerated corrosion (FAC) risks so far as is reasonably practicable (SFAIRP)
Technical Area(s)	Reactor Chemistry
Revision:	0
Overall RO Closure Date (Planned):	2021-04-30
Linked RQ(s)	RQ-UKHPR1000-0094 (CM9 2018/199866), RQ-UKHPR1000-0457 (CM9 2019/354408), RQ-UKHPR1000-0561 (CM9 2020/7196)
Linked RO(s)	
Related Technical Area(s)	Structural Integrity
Other Related Documentation	

Scope of Work

Background

During Steps 2 and 3 of the Generic Design Assessment (GDA), limited information on the consideration of Flow Accelerated Corrosion (FAC) in the UK Version of the Hua-long Pressurized Reactor (UK HPR1000) was provided to ONR. In the current case, the basis for FAC mitigation in the UK HPR1000 is a combination of the selection of FAC resistant materials and the optimisation of pH at a number of FAC susceptible areas. ONR was content that materials selection and chemistry control to minimise FAC susceptibility were reasonable arguments to make during Step 3, on the basis that further details of the analysis carried out and substantiation for these arguments would be presented in future submissions. RQs (RQ-UKHPR1000-0457 (Ref.1) and RQ-UKHPR1000-0561 (Ref.2)) raised towards the end of Step 3 requesting details of the evidence supporting claims and arguments relating to FAC were responded to; however, ONR considered the responses insufficient and required further evidence to support claims/arguments in the context of FAC. Evidence regarding FAC analysis that adequately identifies and assesses FAC susceptible areas of the plant and the justification provided for the FAC mitigation measures was noted to be of particular importance. ONR concluded that currently, the evidence provided to justify material choices and chemistry is insufficient to demonstrate effective protection of at risk areas of the plant, and required any residual FAC risks that may need to be managed by a future licensee to be identified.

Scope of work

 General Nuclear System	REGULATORY OBSERVATION RESOLUTION PLAN RO-UKHPR1000-0034	Rev.: 0	Page: 2 / 8
		GDA-REC-GNSL-006216	

In accordance with the regulatory actions of regulatory observation RO-UKHPR1000-0034, and regulatory queries RQ-UK HPR1000-0457 (Ref.1) and RQ-UK HPR1000-0561 (Ref.2), suitable and sufficient evidence to support the claims and arguments that material selection, chemistry control and design optimisation reduce FAC risk So Far As is Reasonably Practicable (SFAIRP) in the UK HPR1000 will be provided. As such, the work planned in response to this RO covers the following aspects:

- Approach used to evaluate FAC risks in the UK HPR1000 secondary circuit;
- The systematic evaluation of lines and components in the UK HPR1000 secondary circuit, in order to identify any potential shortfalls with regards to the design for preventing FAC risks in the UK HPR1000 secondary circuit (samples of respective FAC susceptible lines and components are selected based material composition, flow conditions and environment); and
- A review of any identified shortfalls in order to determine whether a design change to enhance materials is required in order to demonstrate degradation by FAC for UK HPR1000 secondary circuit has been reduced As Low As Reasonably Practicable (ALARP).

This resolution plan describes the current plan to address RO-UKHPR1000-0034. However, as the work develops, it may be necessary to adjust or update this plan to align with the latest review schedule in agreement with the regulators.

Deliverable Description

Based on the scope outlined above, the following documents will be produced/updated to address this RO:

New documents:

- Report 1: Approach for Evaluation FAC Risks in UK HPR1000 Secondary Circuit;
- Report 2: Assessment Report for FAC Risks in UK HPR1000 Secondary Circuit; and
- Report 3: ALARP Report for FAC Risks in UK HPR1000 Secondary Circuit.

Existing documents:

- Report 4: ALARP Demonstration Report of PCSR Chapter21; and
- Report 5: Pre-Construction Safety Report Chapter 21 Reactor Chemistry.


The contents of each report and how they address each part of ROA1 is discussed as follows.

RO-UKHPR1000-0034.A1 – Provide suitable and sufficient evidence to support the claims made regarding FAC risks and mitigations in the UK HPR1000 safety case.

Therefore in response to this Regulatory Observation Action (ROA), ONR would expect General Nuclear System Limited (GNSL) to:

ROA1.1: Justify the approach/methodology used to evaluate FAC risks in UK HPR1000, taking into account all relevant influencing factors, for example plant environmental conditions, material composition, and flow conditions;

ROA1.2: Based on the above, identify the lines and components in the UK HPR1000 secondary circuit that are considered susceptible to material degradation by FAC. ONR would expect this to include suitable and sufficient information/evidence pertaining to the severity/likelihood of degradation by FAC;

 General Nuclear System	REGULATORY OBSERVATION RESOLUTION PLAN RO-UKHPR1000-0034	Rev.: 0	Page: 3 / 8
		GDA-REC-GNSL-006216	

ROA1.3: Identify and document the options considered to eliminate, reduce or mitigate the risks of materials degradation due to FAC in the susceptible areas identified;

ROA1.4: Make an appropriate overall demonstration that relevant risks relating to materials degradation by FAC for UK HPR1000 have been reduced SFAIRP. As part of this, provide suitable and sufficient evidence to justify the option(s) selected to eliminate, reduce or mitigate the risks of materials degradation due to FAC. Additionally provide robust evidence of the criteria used in decision making and option selection;

ROA1.5: Demonstrate that any residual risks from FAC have been identified, including identification of further actions or steps that a future Licensee may need to undertake.

Resolution Plan

The design and operation of the plant needs to be considered when assessing how to eliminate, reduce or mitigate the risks of material degradation due to FAC. During the design phase of a power plant, lines and components susceptible to FAC should be identified systematically, and how FAC wear rates can be reduced should be considered for each material composition taking into account the associated environment (water chemistry) and flow conditions. During the power plant operation phase, In-Service Inspection (ISI) of FAC susceptible lines and components identified as being “at risk to FAC” should be performed to make sure that any residual FAC risks from the design phase are being controlled. Although the ISI specification will not be provided during the plant design phase, the RP will develop risk transfer information to inform the future operators of any residual FAC risks there may be in the design of the UK HPR1000.

The secondary circuit systems involved in the FAC analysis for CPR1000 units are listed in Table 1. The systems associated with the lines and components in the UK HPR1000 secondary circuit will be further adjusted based on *Approach for Evaluation FAC Risks in UK HPR1000 Secondary Circuit* and Table 1. CGN will divide the secondary circuit systems into 2 or 3 categories according to the criteria defined and choose 1 or 2 representative FAC-susceptible lines or components within each category.

Table 1 The Secondary Circuit Systems Involved in FAC of CPR1000 Units

System code	System name
ABP	Low Pressure Feedwater Heater System [LPFHS]
ACO	Feedwater Heater Drain Recovery System [FHDRS]
ADG	Feedwater Deaerating Tank and Gas Stripper System [FDTGSS]
AHP	High Pressure Feedwater Heater System [HPFHS]
APA	Motor Driven Feedwater Pump System [MDFPS]
ARE	Main Feedwater Flow Control System [MFFCS]
GPV	Turbine Steam and Drain System [TSDS]
GSS	Moisture Separator Reheater System [MSRS]

 General Nuclear System	REGULATORY OBSERVATION RESOLUTION PLAN RO-UKHPR1000-0034	Rev.: 0	Page: 4 / 8
		GDA-REC-GNSL-006216	

To address this RO, the following phases are described as part of the approach for minimising and mitigating FAC risks in the secondary circuit; the associated flow chart is shown in *Appendix A* and will be added in the document titled *Approach for Evaluation FAC Risks in UK HPR1000 Secondary Circuit*.

- Report 1: *Approach for Evaluation FAC Risks in UK HPR1000 Secondary Circuit* will outline how FAC risks have been evaluated in the UK HPR1000 and will respond directly to **ROA1.1**. The main contents of this report will be as follows:

- a) The FAC mechanism, the FAC process and their consequence for SSCs, taking into account plant material selection, water chemistry and flow conditions will be detailed;
- b) The criteria (such as environment, material compositions and flow conditions) for identifying FAC-susceptible lines and components will be outlined and justified, and an explanation as to their impact on FAC provided;
- c) The ranking procedure for FAC-susceptible lines and components that have been identified, which consider the severity/likelihood of degradation by FAC will be outlined;
- d) The strategy to be applied that ensures FAC rates are reduced ALARP for all FAC-susceptible lines and components; and
- e) To identify the residual risks from FAC and the threshold of residual risks from FAC.

- Report 2: *Assessment Report for FAC Risks in UK HPR1000 Secondary Circuit* will outline the assessment process and results from the application of the strategy stated in the *Approach for Evaluation FAC Risks in UK HPR1000 Secondary Circuit* report. The representative FAC-susceptible lines and components will be sampled and addressed. This report will respond to **ROA1.2**. The main contents of this report will be as follows:

- a) A systematic assessment of FAC will be carried out for lines and components in the UK HPR1000 secondary circuit required to comply with the approach defined in Report 1. The secondary circuit systems will be divided into 2 or 3 categories according to the criteria defined and then 1 or 2 representative FAC-susceptible lines or components within each category will be selected and the FAC risks will be evaluated;
- b) The impacts or limitations of the current design with respect to material selection including the technical requirements (mainly chromium content) and manufacturability will be reviewed;
- c) The impacts or limitations of the current design with respect to water chemistry including the pH at operating temperature, hydrazine and oxygen, will be reviewed;
- d) The impacts or limitations of the current design with respect to flow conditions will be reviewed, including:
 - Fluid characteristic parameters: fluid medium, fluid quality, flow rate and temperature;
 - Properties of pipe components: bend, tee, orifice plate, valve, etc.
- e) Sensitivity analysis will be undertaken to analyse any potential cliff edge effects for assumptions/criteria where uncertainty remains; and
- f) Any potential FAC problems or shortfalls where there is a gap against the requirements defined in

 General Nuclear System	REGULATORY OBSERVATION RESOLUTION PLAN RO-UKHPR1000-0034	Rev.: 0	Page: 5 / 8
		GDA-REC-GNSL-006216	


Report 1 will be identified giving rise to a list of gaps that will be analysed further in Report 3.

- Report 3: *ALARP Report for FAC Risks in UK HPR1000 Secondary Circuit* will make an appropriate overall demonstration that relevant risks relating to materials degradation by FAC for UK HPR1000 have been reduced ALARP. This report will respond to **ROA1.3, ROA1.4 and ROA1.5**. The gap list from Report 2 will be used as the starting point for Report 3, which summarises all FAC-susceptible areas in the UK HPR1000. The main contents of this report will be as follows:
 - a) A review of worldwide OPEX on FAC including FAC significant events in other nuclear power plant and mitigations;
 - b) The various options to minimise or remove FAC will be described (including the identification of potential design changes);
 - c) The options identified will be compared and the benefits and disbenefits associated with each option assessed for each gap; the ALARP report related to FAC from all relevant technical areas/disciplines, such as work team from Reactor Chemistry, Structural Integrity, Mechanical Engineering etc. will be integrated;
 - d) A number of procedures and processes set out how an activity is to be undertaken during GDA. These are mandatory and are part of the overall strategy and project arrangements for GDA. The most relevant ones for demonstrating that material degradation by FAC has been minimised SFAIRP, are the following ones, which are followed consistently in all technical areas (shown above) for UK HPR1000 design and safety case development:
 - (1)ALARP Methodology (GHX00100051DOZJ03GN);
 - (2)ALARP Demonstration Instruction (GHX00100119DOZJ03GN);
 - (3)Provisions on Optioneering process for UK HPR1000 Generic Design Assessment (GDA) Project (GH-40M-018);
 - e) The conclusion for each gap and how it minimises risks SFAIRP will be explained (justify whether it is reasonably practicable to change the design in order to enhance material degradation by FAC); and
 - f) Identification of the secondary risks caused by mitigations and other residual risks from FAC and identification of further actions or steps that a future Licensee may need to undertake.

Based on the above ALARP justifications, and where residual risks have been identified, CGN will first assess design modifications that are reasonably practicable and process these as design changes. Where design modifications are not judged to be reasonably practicable, CGN will propose further activities necessary (such as in-service inspection/monitoring or maintenance) for susceptible lines and components. The residual risks associated with susceptible lines and components will need to be addressed further in the site license phase. These necessary activities will be supplemented to the related safety cases.

Impact on the GDA Submissions

Two existing GDA submissions will be updated as part of the resolution of this RO:

 General Nuclear System	REGULATORY OBSERVATION RESOLUTION PLAN RO-UKHPR1000-0034	Rev.: 0	Page: 6 / 8
		GDA-REC-GNSL-006216	

No.	Title	Revision	Planned Submission Date	Related ROAs
1	ALARP Demonstration Report of PCSR Chapter21	C	31 st December 2020	ROA1.4 and ROA1.5
2	Pre-Construction Safety Report Chapter 21 Reactor Chemistry	V2	Subject to project progress	ROA1.4 and ROA1.5

Three new GDA submissions will be produced as part of the resolution of this RO:

No.	Title	Revision	Planned Submission Date	Related ROAs
1	Approach for Evaluation FAC Risks in UK HPR1000 Secondary Circuit	A	31 st August 2020	ROA1.1
2	Assessment Report for FAC Risks in UK HPR1000 Secondary Circuit	A	31 st October 2020	ROA1.2
3	ALARP Report for FAC Risks in UK HPR1000 Secondary Circuit	A	31 st December 2020	ROA1.3, ROA1.4 and ROA1.5


Timetable and Milestone Programme Leading to the Deliverables

Timetable for all related deliverables is described in the attached Gantt Chart in Appendix B.

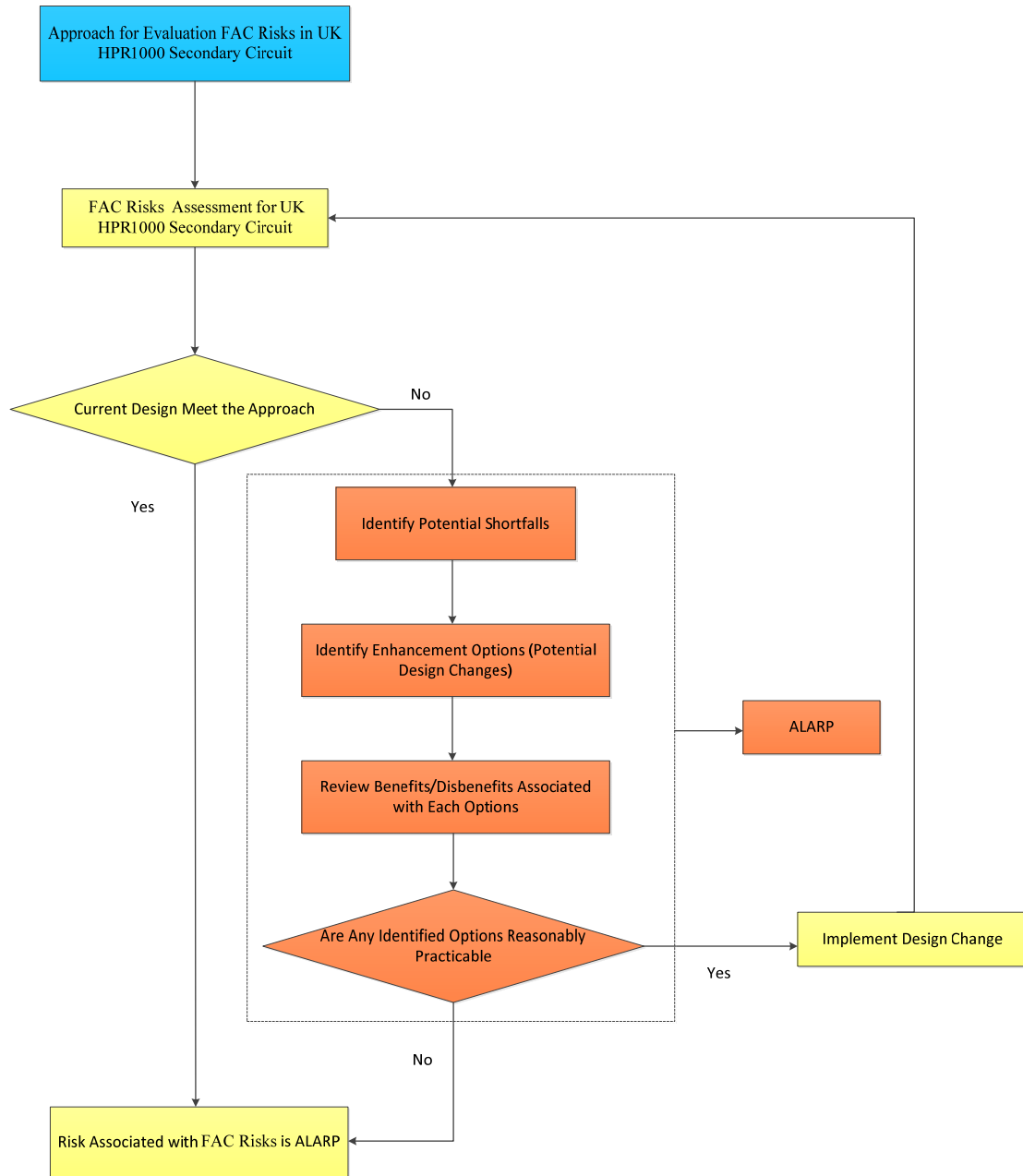
Reference


[1] RQ-UKHPR1000-0457 PCSR Chapter 21 Queries, Full Response, 29 November 2019. CM9 ref. 2019/354408.

[2] RQ-UKHPR1000-0561 Follow-up Query on Secondary Circuit Chemistry FAC, Full Response, 6 January 2020. CM9 ref. 2020/7196.

 General Nuclear System	REGULATORY OBSERVATION RESOLUTION PLAN RO-UKHPR1000-0034	Rev.: 0	Page: 7 / 8
		GDA-REC-GNSL-006216	

APPENDIX A Flowchart of Approach to Enhance the Material Degradation by FAC



	REGULATORY OBSERVATION RESOLUTION PLAN RO-UKHPR1000-0034	Rev.: 0	Page: 8 / 8
		GDA-REC-GNSL-006216	

APPENDIX B RO-UKHPR1000-0034 Resolution Plan Gantt Chart

Tasks	Steps	2020												2021					
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Preparation of Submission and Closure of RO Action																			
Approach for Evaluation FAC Risks in UK HPR1000 Secondary Circuit, Rev. A	Development																		
	Submission								▲										
Assessment Report for FAC Risks in UK HPR1000 Secondary Circuit, Rev. A	Development																		
	Submission										▲								
ALARP Report for FAC Risks in UK HPR1000 Secondary Circuit, Rev. A	Development																		
	Submission												▲						
ALARP Demonstration Report of PCSR Chapter21.	Development																		
	Submission												▲						
Assessment																			
Regulators assessment																			
Target RO closure Date																		▲	