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		GDA-REC-GNSL-006150	

REGULATORY OBSERVATION Resolution Plan	
RO Unique No.:	RO-UKHPR1000-0033
RO Title:	Steam Generator Code Provisions and Mitigation of Relevant Risks
Technical Area(s)	Structural Integrity
Revision:	0
Overall RO Closure Date (Planned):	2021-01-29
Linked RQ(s)	RQ-UKHPR1000-0277, RQ-UKHPR1000-0219, RQ-UKHPR1000-0109, RQ-UKHPR1000-0030
Linked RO(s)	
Related Technical Area(s)	Fault Studies, Internal Hazards, MSQA, Mechanical Engineering
Other Related Documentation	
Scope of Work	

Background

The design, manufacture, inspection, testing, installation and proposed operation of nuclear island equipment for Fangchenggang Unit 3 (FCG-3), the reference plant for the UK HPR1000, are mainly based on the French codes/standards RCC-M 2007, RSE-M 2010 and 2012 Addendum (Ref.1 and 2). However, General Nuclear Services Ltd (GNSL), the requesting party (RP) for the UK HPR1000, is proposing that as with FCG-3, the SGs for the UK HPR1000 are designed and manufactured to the United States codes ASME III 2007 and 2008 Addendum (Ref.3), but with pre-service (PSI) and in-service inspection (ISI) to the rules of the French RSE-M code i.e. to use a combination of American and French codes/standards.

In Step 2 of the Generic Design Assessment (GDA) of UK HPR1000, ONR asked the RP to explain the basis of their proposals for the SG, and to justify how their selection of codes and standards to underpin the structural integrity case for the SGs, is commensurate with reducing risks so far as is reasonably practicable. For the purpose of this RO, the term as low as reasonably practicable (ALARP) is used for brevity (Ref. 4 and 5). ONR emphasised that combining codes and standards incurs risks that need to be managed through-out the complete life cycle of the component. Similarly, alternative code options, to improve coherency and consistency may also incur risks.

In response, the RP initiated a high-level SG ALARP code assessment, and with input from an expert panel, considered four SG code options (Ref. 6):

- Option 1 – reference design (FCG3) ASME III design and RSE-M for PSI/ISI;

- Option 2 – reference design but ASME Section XI for PSI/ISI (design, manufacture, ISI to ASME);
- Option 3 – reference design but re-design to follow RCC-M/RSE-M (design, manufacture, ISI); and
- Option 4 – re-design a new SG following RCC-M/RSE-M (design, manufacture, ISI)

The RP concluded that as with the reference FCG-3 design, Option 1 was their preferred option for the UK HPR1000. This option includes supplementing full compliance with the ASME code for design and manufacture with additional measures from RCC-M and RSE-M.

ONR concluded that there is no evidence from Ref. 6 to suggest that Option 1 is derived from *'cherry picking'*; i.e. where selective and more lenient aspects of codes and standards are chosen with the resulting collective provisions potentially providing an inadequate basis to justify integrity. ONR therefore considers that Option 1 could be a viable SG code option for the UK HPR1000. Nonetheless, in reviewing Ref.6, ONR identified points to follow-up covering: the due process, management of risks; and specific design questions.

ONR considers the current uncertainties relating to the adequacy of the RP's consideration of relevant risks relating to the SG code provisions and their mitigation represent potential shortfalls in the safety case for the UK HPR1000 SG. As this is setting a precedent in the UK for a component subject to a highest reliability claim, this Regulatory Observation (RO) is raised to:

- Articulate ONR's regulatory expectations;
- Gain further explanation and assurance in the RP's process and consideration of relevant risks relating to the SG code provisions.
- Ensure that the risks associated with the RP's preferred SG code ALARP option for the UK HPR1000 are reduced to ALARP.

In order to address RO-UKHPR1000-0033 and to achieve ONR's expectations, this resolution plan is developed to outline the programme of work. The work to address each action of the RO is detailed below.

Abbreviations and Acronyms

ALARP	As Low As Reasonably Practicable
ASME	American Society of Mechanical Engineers (ASME) Codes
CSR	Component Safety Report
EIMT	Examination, Inspection Maintenance and Testing
ENIQ	European Network for Inspection and Qualification
FCG -3	Fangchenggang nuclear power plant Unit 3
GDA	Generic Design Assessment
GNSL	General Nuclear Services Ltd

HIC	High Integrity Component
HPR1000	Hua-long Pressurized Reactor under construction at Fangchenggang nuclear Power Plant unit 3
ISI	In-Service Inspection
NDT	Non-Destructive Testing
NNSA	National Nuclear Safety Administration
OPEX	Operating Experience
ONR	Office for Nuclear Regulation
PSI	Pre-Service Inspection
QA	Quality Assurance
RCC-M	Design and Construction Rules for Mechanical Components of PWR Nuclear Islands
RO	Regulatory Observation
RP	Requesting Party
RQ	Regulatory Query
RSE-M	In-service Inspection Rules for Mechanical Components of PWR Nuclear Islands
SG	Steam Generator
SI	Structural Integrity
SIC	Structural Integrity Class
SSC	Structures, Systems and Components
UK	United Kingdom of Great Britain and Northern Ireland
UK HPR1000	The UK Version of the Hua-long Pressurized Reactor
US	United States

Scope of work

In accordance with the regulatory observation actions of RO-UKHPR1000-0033, the RP will clarify the process for identifying the SG code relevant risks, and provide detailed evidence to demonstrate that SG code provisions and mitigation of relevant risks have been addressed. The scope of work in this resolution plan covers following aspects:

1) The approach to identifying the SG Code relevant risks and the key steps in the process.

2) Identifying the codes and standards jurisdiction of ASME/RCCM/RSE-M.

3) Identifying the key code gaps between ASME and RCC-M/RSE-M (Related to SG).

4) Identifying and judging the aspects of risks in design, material procurement, fabrication, welding, non-destructive testing, PSI, EIMT and QA, etc.

5) Mitigation measures for the risks in SG design, material procurement, fabrication, welding, non-destructive testing, PSI, installation, EIMT and QA, etc.

6) Provisions for the SG design, material procurement, fabrication, welding, non-destructive testing, PSI, installation, EIMT and QA,etc. to reduce risks to ALARP.

On the basis of the documentation submitted prior to Step 4 and the planned Step 4 submissions of GDA, and taking cognisance of the regulatory expectations, the following documents will be updated or produced to address this RO and achieve ONR's regulatory expectations.

1) QA Requirements for SG Design, Manufacture and Plant Construction
2) The Risk Analysis and Mitigation Measures of SG Codes
3) The SG Code Relevant Risks Analysis and Assessment Report
4) SG Component Safety Report (revised)
5) SG Design Specification (revised)

This Resolution Plan describes the current plan to address RO-UKHPR1000-0033. 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

The main actions required to resolve this RO are described as follows.

RO-UKHPR1000-033.A1 – Process for the consideration of SG code relevant risks.

In response to this ROA, the RP should provide:

- *A further explanation of the process for identifying the SG code relevant risks, the topic areas considered and their significance in terms of ensuring the adequacy of the SG code provisions for the UK HPR1000. This should include, but not be limited to: physical interfaces/code juridictions, QA and organisational responsibilities, EIMT provsions, and the phyical/organisational arrangements to ensure that a highest reliability case for the high integrity components in the SG can be developed.*

RO-UKHPR1000-033.A2 – SG code provisions and mitigation of relevant risks

The RP has classified the certain SG primary and secondary pressure boundary components as a high integrity components (HIC), akin to a highest relaibility claim in the UK. This is an onerous route to a safety justification, with the expecation of measures above and beyond normal practice i.e. in nuclear design codes and stanadards. Thus, as with other HIC components, there needs to be a sound basis for the development *and future implementation of these additional measures to infer highest reliability: surveillance activities, and as appropriate, additional design, manufacture and inspection measures.*

ONR considers that the response to this Action should include information on:

- *the measures taken to eliminate or reduce SG code relevant risks to ALARP;*
- *the scope of the additional measures expected to underpin the HIC classification for SG components, along with how they will be implemented and controlled during design, manufacture, and installation to support a future licensee, and*
- *how the claims, arguments and evidence undepinning the RP's position and mitigation measures will be documented in the generic safety case.*

In response to this ROA, the RP should provide:

- ***RO-UKHPR1000-0033.A2.1:** A demonstration that SG code relevant risks with the potential to affect the achievement of the design intent have been considered and that an adequate highest reliability claim for the UK HPR1000 SGs can be provided with relevant risks avoided, or reduced to ALARP.*
- ***RO-UKHPR1000-0033.A2.2:** An explanation of the process for taking account of the impact of future changes in the design, manufacturing and inspection provisions of the proposed codes e.g. ASME III/XI and RCC-M/RSE-M, on the UK HPR1000 SGs, and how these will be captured in the safety case.*

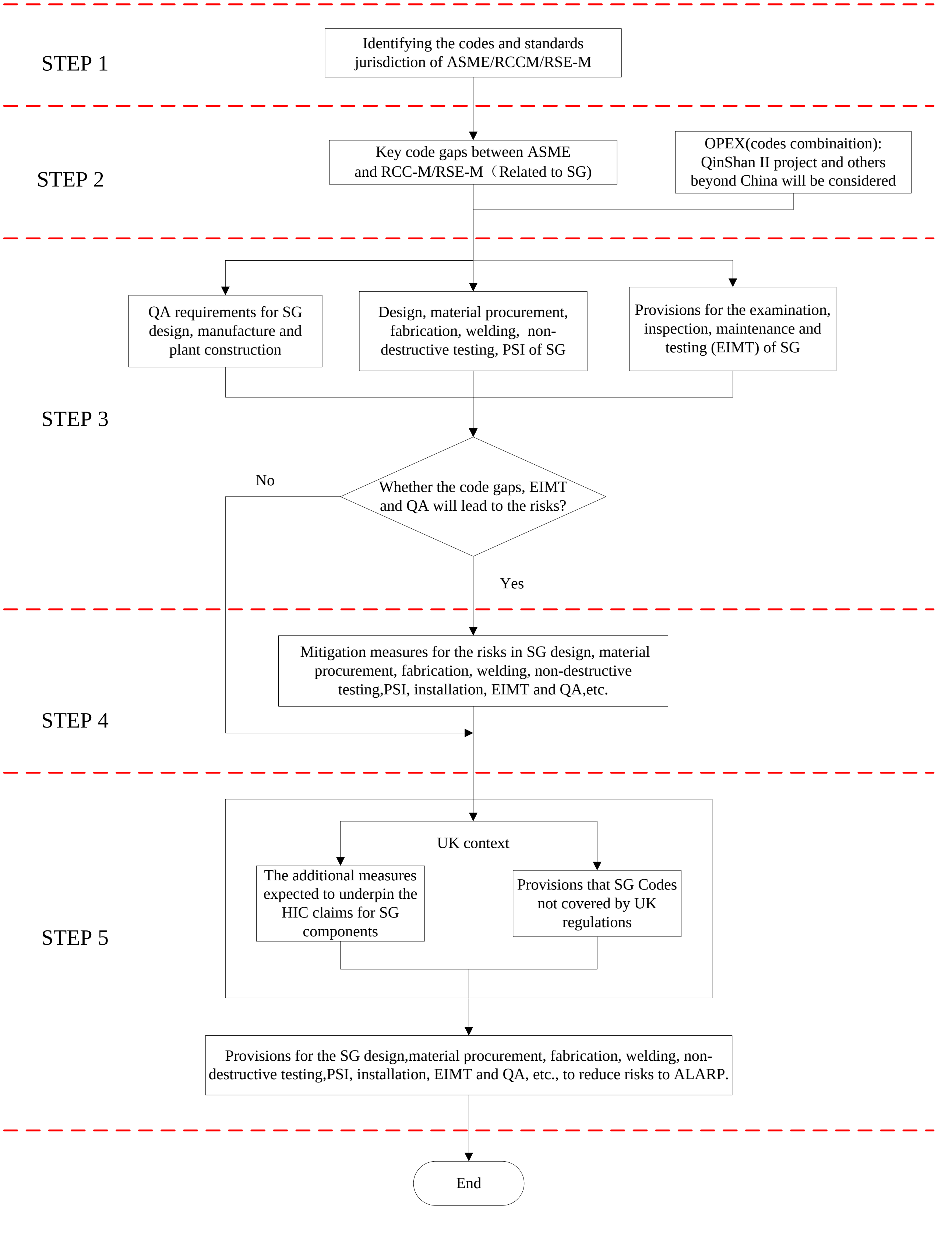
Resolution Plan:

In response to **RO-UKHPR1000-0033.A1** and **RO-UKHPR1000-0033.A2.1**:

Both RCC-M and ASME are internationally widely-used codes for nuclear components design and construction to assure high quality of components. The HPR1000 (FCG3) steam generator (SG) (as Reference Design for UK HPR 1000 SG) is designed and constructed according to ASME code with some additional requirements from RCC-M/RSE-M code. The reasons for choosing ASME code and the rationale for supplementing the ASME III design and construction code with additional measures from the RCC-M code are described in detail in the response to query RQ-UKHPR1000-0109. RSE-M code is used for PSI and ISI of the SG, which is based on the engineering application experience in previous PWR reactors. This codes selection scheme is used to meet the expectations of the National Nuclear Safety Administration (NNSA) in China and has been successfully used in the QinShan Phase II Project which has been operated for about 16 years.

For the UK HPR1000 SG, the RP concludes that SG code provisions should be the same as the Reference Design. This is supported by the ***High Level ALARP Assessment for SG Code*** (Ref.6) and based on RP's design and construction experience. Thus, the SG for the UK HPR1000 is designed and manufactured according to ASME III, with PSI/ISI according to RSE-M code. In addition, PSI according to ASME III (In section NB 5280, components shall be examined as specified in ASME XI) will also be performed after hydrotest of SG at the shop. Additional requirements from RCC-M or RSE-M codes will be considered in SG design and construction, which are confirmed as good practices and justified as necessary to improve the quality and control of SG construction. With full compliance with the ASME code and enhanced by additional RCC-M/RSE-M requirements, the risks caused by using different codes between the SG and other UK HPR1000 structures is assessed to be eliminated or reduced.

The design, manufacture and plant construction of nuclear island main equipment of HPR1000 (FCG3), the reference plant for the UK HPR1000, are mainly based on French RCC-M 2007, RSE-M 2010 and 2012 Addendum. However, Steam Generator (SG) for HPR1000 is designed and manufactured to the US ASME III 2007 and 2008 Addendum, but with PSI and ISI to the French RSE-M code. The combination of American and French codes/standards may lead to potential risks arisng from gaps in the SI provisions, EIMT, and QA etc.. In order to identify, eliminate and mitigate potential risks and informed by relevant OPEX, the rationale/approach and key steps in the process to address ROA1 and ROA2.1 will be addressed as outlined in the flowchart below.



STEP 1
Identifying the codes and standards jurisdiction of ASME/RCCM/RSE-M
STEP 2
Key code gaps between ASME and RCC-M/RSE-M（Related to SG)
OPEX(codes combinaition): QinShan II project and others beyond China will be considered
STEP 3
QA requirements for SG design, manufacture and plant construction
Design, material procurement, fabrication, welding, non-destructive testing, PSI of SG
Provisions for the examination, inspection, maintenance and testing (EIMT) of SG
Whether the code gaps, EIMT and QA will lead to the risks?
No
Yes
STEP 4
Mitigation measures for the risks in SG design, material procurement, fabrication, welding, non-destructive testing,PSI, installation, EIMT and QA,etc.
STEP 5
UK context
The additional measures expected to underpin the HIC claims for SG components
Provisions that SG Codes not covered by UK regulations
Provisions for the SG design,material procurement, fabrication, welding, non-destructive testing,PSI, installation, EIMT and QA, etc., to reduce risks to ALARP.
End

The key steps are described below:

Step 1: Identifying the codes and standards jurisdiction of ASME/RCCM/RSE-M.

This step is to identify the codes and standards jurisdiction of ASME/RCCM/RSE-M. The interfaces between SG vessel and pipework due to different SSC code provisions will be clearly listed and explained which are applicable to ASME/RCCM/RSE-M.

Step 2: Identifying the key code gaps between ASME and RCC-M/RSE-M (Related to SG).

The comparison shall include at least:

1) The key code gaps between ASME III and RCC-M section B for the design, manufacture and plant construction of SG.
2) The key code gaps between ASME XI and RSE-M for PSI of SG.
3) The RP will collect all significant relevant reports and RQs in Step 3 of GDA. The RP will study the relevant OPEX and apply the lessons to ensure relevant risks are considered. The scope of OPEX is not just limited to Chinese experience but also the others beyond China.

Step 3: Identifying and judging the aspects of risks in design, material procurement, fabrication, welding, non-destructive testing, PSI, EIMT and QA, etc.

The judgement for the aspects of risks shall be based on:

1) The requirements for design, material procurement, fabrication, welding, non-destructive testing, and PSI of SG.
2) Different QA requirements for SG design, manufacture and plant construction. The QA requirements and organisational responsibilities shall be identified in this sub-step.
3) Provisions for the examination, inspection, maintenance and testing (EIMT).

Step 4: Mitigation measures as appropriate to address the risks in SG design, material procurement, fabrication, welding, non-destructive testing, PSI, installation, EIMT and QA, etc.

This will include, but not limited to:

1) The mitigation measures for the risks in SG design, material procurement, fabrication, welding, non-destructive testing, and PSI corresponding to the identified aspects of risks in Step 3.
   The ASME Code shall be reconciled with the RCC-M Code regarding the detailed design requirements for SG pressure boundary and general requirements for construction of pressure vessels. Supplementary design requirements applied from RCC-M/RSE-M shall be identified.
2) Risks about different QA requirements for SG design, manufacture and plant construction.
   The QA requirements and organisational responsibilities shall be identified in this sub-step. This includes, but not limited to:
   - The sources of quality assurance and control requirements (at a high level).
   - Surveillance of activities by or for the owner and the contractor or suppliers.
   - Control and surveillance of the design, manufacture, inspection, and/or testing of SG.

   A document named ***QA Requirements for SG Design, Manufacture and Plant Construction*** will be issued for this aspect.

3) Provisions for the examination, inspection, maintenance and testing (EIMT).

The EIMT requirements for SG pressure boundary shall be specified in the ***Design Specification of Steam Generator***(Ref.7) and ***Steam Generator Component Safety Report*** (Ref.8). These two documents will be revised if necessary, considering the impact of this evidence. Since SG internals are not covered in both the ASME and RCC-M Code, the EIMT requirements for SG internals shall be determined according to the experience of designer and plant operational experience.

A document named ***The Risk Analysis and Mitigation Measures of SG Codes*** will be issued in this step.

Step 5: Provisions for the SG design, material procurement, fabrication, welding, non-destructive testing,PSI, installation, EIMT and QA,etc. to reduce risks to ALARP.

The provisions discussed in this step shall comply with the following requirements from UK context:

1) The additional measures expected to underpin their HIC claims for SG components.

Compared with SIC-1/SIC-2/SIC-3 components, HIC components require a more demanding integrity demonstration to ensure that the component remains as defect free as possible and is defect tolerant. The justifications are presented in the form of safety claims, supporting arguments and evidences. Detailed information of claims, arguments and evidences can be found in ***Safety Case Methodology for HIC and SIC components*** (Ref.9) and ***Steam Generator Component Safety Report*** (Ref.8). To achieve a high quality of design and manufacture, HIC components comply with the requirements of relevant, mature and widely-used nuclear codes and standards as a sound foundation for the structural integrity case. Additional measures exceeding the requirements of codes are identified and implemented as follows:

- The appropriate supplementary fracture toughness test for HIC component material will be determined and implemented at the product manufacture stage.
- Inspection qualification according to ENIQ methodology will be used to achieve the reliability of objective-based manufacturing NDT and during service.
- Defect tolerance is to be substantiated by defect tolerance assessments.
- Independent third party inspection (surveillance) of design and manufacturing activities.

2) Provisions that SG Codes not covered by UK regulations

This recognition shall be performed in accordance with the response to RQ-UKHPR1000-0463. However, it is recognised that for the SG the proposed code provisions go beyond those of other major vessels in the UK HPR1000, which are designed and manufactured to the RCC-M code. So, a further explanation for SG will be addressed in this step.

A final report named ***The SG Code Relevant Risks Analysis and Assessment Report***, which will consider UK context and identify all code relevant risks and then analyse and demonstrate these risks are reduced to ALARP, will be issued in this step to support and supplement the ***High Level ALARP Assessment for SG Code*** (Ref.6).

In response to **RO-UKHPR1000-0033.A2.2**:

In order to ensure the adequate implementation of the design rules and requirements of Codes/Standards used on the UK HPR1000 SGs, the RP will continuously track the updating of the Codes/Standards and reflect the comparison and updating of ASME III/XI and RCC-M/RSE-M in the document ***Suitability Analysis of Codes and Standards in Structural Integrity*** (Ref.10), which is referenced in the PCSR Chapter 17. In the document Ref.10, the comparison of RCC-M, RSE-M, ASME are referred to, so the changes can be captured in the safety case.

Impact on the GDA Submissions

The supporting submissions are involved in this resolution plan.

The impact of this evidence on other key safety case submissions e.g. the SG Component Safety report and SG Design Specification shall be addressed, and the affected SG documents will be revised if necessary. Relevant information shall be incorporated into the final version of Chapter 17 submissions during Step 4 of GDA.

GDA Submission Document	Related ROAs	Planned schedule for submission
QA Requirements for SG Design, Manufacture and Plant Construction	ROA1& ROA2	31st July 2020
The Risk Analysis and Mitigation Measures of SG Codes	ROA1& ROA2	31st July 2020
The SG Code Relevant Risks Analysis and Assessment report	ROA1& ROA2	30th September 2020
SG Component Safety report (revised)	ROA1& ROA2	30th September 2020
SG Design Specification (revised)	ROA1& ROA2	30th September 2020

Timetable and Milestone Programme Leading to the Deliverables

The Gantt Chart is presented in APPENDIX A.

References

[1] RCC-M. Design and Construction Rules for Mechanical Components of PWR Nuclear Islands. 2007 Edition. Published by the French Association for Design, Construction and In-Service Inspection Rules for Nuclear Island Components – AFCEN, Paris.

[2] RSE-M. In-Service Inspection Rules for Mechanical Components of PWR Nuclear Islands, RSE-M, 2010 edition+2012 addendum, 2010, 2012, AFCEN.

[3] ASME, American Society of Mechanical Engineers Codes, 2007 edition+2008 Addenda

[4] RQ-UKHPR1000-0030, Proposed Design and Construction Codes in the UK HPR1000 Structural Integrity Case, (2018/87899)

[5] RQ-UKHPR1000-0109, Proposed Design and Construction Codes in the UK HPR1000 Structural Integrity Case, (2018/198542)

[6] High Level ALARP Assessment for SG Code, GHX44300003DPZS44DS , Rev. B, 2018

[7] Design Specification of Steam Generator, GHX44300005DPZS03GN, Rev. A, 2019

[8] Steam Generator Component Safety Report, GHX00100103DPZS03GN, Rev. D, 2019

[9] Safety Case Methodology for HIC and SIC components, GHX00100001DPFJ44DS ,Rev. D, 2019

[10] Suitability Analysis of Codes and Standards in Structural Integrity, GHX00800013DPFJ02GN, Rev. A, 2018

APPENDIX A RO-UKHPR1000-0033 Gantt Chart

Task and Schedule		2020												2021	
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
RO Action 1&2															
1	Development of deliverable- [QA Requirements for SG Design, Manufacture and Plant Construction]														
	Submission of deliverable- [QA Requirements for SG Design, Manufacture and Plant Construction]														
2	Development of deliverable-[The Risk Analysis and Mitigation Measures of SG Codes]														
	Development of deliverable-[The Risk Analysis and Mitigation measures of SG codes]														
3	Development of deliverable-[The SG Code Relevant Risks Analysis and Assessment Report]														
	Submission of deliverable-[The SG Code Relevant Risks Analysis and Assessment Report]]														
4	Development of deliverable-[SG Component Safety report (revised)]														
	Submission of deliverable-[SG Component Safety report (revised)]														
5	Development of deliverable-[SG Design Specification (revised)]														
	Submission of deliverable-[SG Design Specification (revised)]														
Assessment															
	Regulatory Assessment														
	Target RO Closure Date														