

 General Nuclear System	REGULATORY OBSERVATION RESOLUTION PLAN RO-UKHPR1000-0021	Rev.: 0	Page: 1 / 11
		GDA/REC/GNS/005378	

REGULATORY OBSERVATION Resolution Plan	
RO Unique No.:	RO-UKHPR1000-0021
RO Title:	Demonstration of the adequacy of Examination, Maintenance, Inspection and Testing (EMIT) of structures, systems and components important to safety
Technical Area(s)	Fault Studies
Revision:	0
Overall RO Closure Date (Planned):	31/03/2021
Linked RQ(s)	RQ-UKHPR1000-0084, RQ-UKHPR1000-0171
Linked RO(s)	RO-UKHPR1000-0004.A4
Related Technical Area(s)	2. Civil Engineering 3. Control & Instrumentation 6. Cross Cutting 7. Electrical Engineering 14. Mechanical Engineering 15. Probabilistic Safety Analysis 16. Radiological Protection 20. Structural Integrity
Other Related Documentation	-
Scope of Work	
<p><u>Background</u></p> <p>Safety Assessment Principles (SAPs) [1] includes ONR's regulatory expectations to consider Examination, Maintenance, Inspection and Testing (EMIT) within the safety case.</p> <p>The reference plant (FCG3) of UK HPR1000 has considered the design of EMIT. The EMIT windows are derived from deterministic safety analysis, and the EMIT requirements of systems (activities, frequency and duration, etc.) are identified to ensure that the assumptions in deterministic safety analysis are achieved.</p> <p>On the basis of the reference plant, RP has proposed the arrangement of EMIT concerning methodology for the Periodic Test, In-service Inspection and Maintenance of Structures, Systems and Components in the PCSR 31 Operational Management [2] for the UK HPR1000. The principles and requirements of EMIT are made in accordance with Chinese experience. In principle, safety analysis</p>	

 General Nuclear System	REGULATORY OBSERVATION RESOLUTION PLAN RO-UKHPR1000-0021	Rev.: 0	Page: 2 / 11
		GDA/REC/GNS/005378	

and the EMIT arrangement are consistent. Thus the safety systems required in design basic condition are designed to enable maintenance during outage while the safety function is not needed, and to enable testing and inspection which do not induce safety function unavailability during all operating modes (such as power operation, shutdown and start-up, etc.). They are also designed with redundancy of 3 trains to enable the safety function to be delivered in the event of a train failure while another train is influenced by the initiating event.

In the UK HPR1000, ONR has indicated that “*it is unclear how the RP intends to identify the permitted combinations of equipment unavailability for each permitted operating state*”. ONR therefore raised this RO to obtain the EMIT strategy and its substantiation.

RP has realised that the organisation and presentation of EMIT safety case, and the UK specific requirements related to EMIT are not shown in a clear way in safety case. In order to fill these shortfalls, the resolution plan action 1 provides a report *Examination, Maintenance, Inspection and Testing (EMIT) Strategy to show* a clearer arrangement of EMIT, and then resolution plan action 2 provides the analysis of EMIT to demonstrate the consistency of all relevant technical disciplines.

This resolution plan is provided as a response to ONR’s expectations on EMIT consideration within the safety case.

Abbreviations and Acronyms

CGN	China General Nuclear Power Corporation
EMIT	Examination, Maintenance, Inspection and Testing
FCG3	Fangchenggang Nuclear Power Plant Unit 3
GDA	Generic Design Assessment
ISI	In-Service Inspection
MCS	Maintenance Cold Shutdown
NS/SG	Normal Shutdown with Steam Generators
NS/RIS-RHR	Normal Shutdown with RIS-RHR
ONR	Office for Nuclear Regulation (UK)
OTS	Operating Technical Specification
OPEX	Operating Experience
PCSR	Pre-Construction Safety Report
PSA	Probabilistic Safety Assessment
PSI	Pre-Service Inspection
RCS	Refuelling Cold Shutdown
RCD	Reactor Completely Discharge
RO	Regulatory Observation
RP	Requesting Party
SAP	Safety Assessment Principles
SSC	Structures, Systems and Components
UK HPR1000	UK Version of the Hua-long Pressurised Reactor

Scope of work

 General Nuclear System	REGULATORY OBSERVATION RESOLUTION PLAN RO-UKHPR1000-0021	Rev.: 0	Page: 3 / 11
		GDA/REC/GNS/005378	

This Resolution Plan describes the current plan to address RO-UKHPR1000-0021. It contains the EMIT strategy, key tasks and planned activities associated with the specified actions.

Deliverable Description

RO-UKHPR1000-0021. A1 - Examination, Maintenance, Inspection and Testing (EMIT) Strategy


The RO action 1 states that:

In response to this Regulatory Observation Action, RP should:

- a) *Provide a strategy which explains how EMIT will be derived, justified and included within the safety case for the generic UK HPR1000 design. This should adequately describe the scope of the EMIT aspects of the safety case to be produced during GDA, and what is proposed to be carried over to site specific stages. The information provided should enable ONR to judge whether a suitable and sufficient safety case will be produced that is likely to meet UK legal requirements and regulatory expectations.*
- b) *ONR considers that the response to this Action should include information on:*
 - *How UK specific legal requirements related to EMIT will be identified and addressed within the generic safety case.*
 - *The intended operating profile assumed for the design and how this relates to EMIT, including refuelling outages and maintenance windows, as appropriate.*
 - *An explanation and justification of the underpinning rationale (philosophy) for EMIT of SSCs important to safety in the UK HPR1000 design and how this is consistent with the safety analysis.*
 - *How EMIT requirements for SSCs important to safety will be derived during GDA, taking into account relevant factors such as good practice or likely (key) supplier or manufacturer requirements.*
 - *How codes and standards will inform the development of EMIT requirements.*
 - *How the safety case will demonstrate that the regulatory expectations of the SAPs will be met, in particular those SAPs detailed above.*
 - *How any EMIT will be captured as part of the generic safety case produced during GDA, and how these could be further developed by a future licensee as part of site specific stages.*
 - *How operating rules will be informed by EMIT requirements.*

Resolution Plan Action 1

RP will respond to this action by delivering a report *Examination, Maintenance, Inspection and Testing (EMIT) Strategy*, which is undertaken in the cross cutting areas, and is jointly developed by Fault Studies, Control & Instrumentation, Electrical Engineering, Mechanical Engineering, Probabilistic Safety Analysis, Civil Engineering, Radiological Protection, Structural Integrity, Human Factors, Radwaste, Decommissioning and Spent Fuel Management. Based on the experience of the reference plant and the UK requirements, *Examination, Maintenance, Inspection and Testing (EMIT)*

 General Nuclear System	REGULATORY OBSERVATION RESOLUTION PLAN RO-UKHPR1000-0021	Rev.: 0	Page: 4 / 11
		GDA/REC/GNS/005378	

Strategy is developed to present a clear arrangement of EMIT. The *Examination, Maintenance, Inspection and Testing (EMIT) Strategy* explains what the experiences of EMIT design in FCG3 and the EMIT philosophies in UK HPR1000 are, and justifies how EMIT requirements are derived and linked to each relevant disciplines (safety analysis, PSA, SSC design, layout, radiological protection, human factors, operating profile) within safety case in UK HPR1000. *Examination, Maintenance, Inspection and Testing (EMIT) Strategy* includes five major parts: EMIT philosophies, UK requirements identification, EMIT safety case development process, EMIT documentations hierarchy, and EMIT scope.

- a) Firstly, the EMIT philosophies which have been implemented and achieved in China's nuclear power plant, will be introduced with the basis of EMIT principle and arrangement in UK HPR1000.
- b) Secondly, the UK requirements will be reviewed to identify any potential gap within current Examination, Maintenance, Inspection and Testing (EMIT) Strategy of UK HPR1000. And these UK requirements are part of the input data to define the EMIT activities, frequency especially when UK requirements of EMIT are specific. Beside the above legislations, codes and standards, the regulatory expectations in SAP will also be considered to make sure UK HPR1000 EMIT arrangements meet regulatory expectations.
- c) EMIT safety case development process is drawn to show its logic, how EMIT links to the relevant disciplines within safety case and what EMIT work will be done during and after GDA. The EMIT safety case management and delivery please refers to the response of RO-UKHPR1000-0004 Action 4_Capturing Assumptions, Requirements and Commitments from the Safety Case. The figure F-1, which will be explained in more details of each step in the *Examination, Maintenance, Inspection and Testing (EMIT) Strategy*, shows EMIT design process to enable the designer and future licensee to develop EMIT requirements. Explanations of major steps of the process are provided as follows.

Box 0 UK legislations, codes and standards

UK legislations, codes and standards are identified and reviewed to set out UK specific requirements, and used as part of the input to define the EMIT requirements (activities, frequency, window).

Box 1 EMIT general principles

EMIT general principles include the general design objectives, philosophies, scope of work, categories of activities, etc. in respect of testing, inspection (including examination), and maintenance. The principles are produced according to general safety requirements, UK legal requirements, and operating experiences in existing nuclear power plants in China. EMIT general principles are used to further develop EMIT methodologies.

Box 2 EMIT methodologies

Based on the EMIT general principles, the EMIT methodologies are developed to guide the design of periodic test, pre-service and in-service inspection, preventive maintenance. Corresponding to testing, inspection and maintenance, there are three main methodology reports respectively: *Periodic Test Design Methodology* [3], *Outline of PSI and ISI Requirements for UK HPR1000* [4] and *Preventive Maintenance Programme Principle*.

The preliminary version of *Preventive Maintenance Programme Principle* will be provided in the

 General Nuclear System	REGULATORY OBSERVATION RESOLUTION PLAN RO-UKHPR1000-0021	Rev.: 0	Page: 5 / 11
		GDA/REC/GNS/005378	

November of 2019, and the three reports mentioned above will be updated as necessary in the June of 2020 after *Examination, Maintenance, Inspection and Testing (EMIT) Strategy* is finished.

Box 3.1 EMIT activity/frequency/window

The EMIT activity includes the activities of maintenance, testing, inspection of the SSC important to safety. The EMIT frequency means that the planned EMIT activity is carried out at predetermined interval of calendar time, operating time or number of cycles. They are used to ensure that SSC important to safety are available to perform their functions in accordance with the assumptions and intent of the design. The activity and frequency of testing, inspection and preventive maintenance are presented respectively in *Periodic Test Completeness Note (PTCN)*, *Pre-service Inspection List*, and *System Design Manual*, as well as *Strategy of Electrical Power System EMIT* and *Periodic Test Requirement of Protection System (PS)* [5].

EMIT window is a combination of operating modes in which the EMIT activities of certain SSC important to safety are permitted to be carried out. EMIT window is identified in *Examination, Maintenance, Inspection and Testing (EMIT) Windows* to make sure the arrangement of EMIT activities are consistent with deterministic safety analysis.

EMIT activity, frequency, window are also used to develop the plant outage schedule to ensure the arrangement of EMIT can be achieved.

Box 3.2 to 3.10 Relevant disciplines

The design of all the relevant disciplines within safety case shown in the Box 3.2 to 3.10 considers EMIT requirements, and also the EMIT requirements are developed on the basis of human factor, deterministic safety analysis, PSA, SSC design (Mechanical engineering, civil engineering, control & instrumentation, electrical engineering, structural integrity), operating profile, operating experiences, operating rules, radiation protection, layout design, and EMIT methodologies. In particular, the EMIT activity, frequency, window are modelled in PSA to analyse the impact to SSC unavailability caused by EMIT. This process ensures that all the relevant disciplines are consistent within safety case.

Box 3.11 Preliminary outage schedule


Preliminary Outage Schedule is to list the main activities which are performed during plant outage, and is limited to critical path to ensure that the intended operating profile is achievable.

Box 3.12 EMIT requirements conflict with safety case requirements

After the outage schedule is done, the potential risk identification is performed in EMIT by analysis of the consistency between EMIT requirements and other safety case requirements from human factor, radiological protection, layout design, deterministic safety analysis, PSA, SSC design. The document *EMIT Consistency Analysis* is to show whether there is any inconsistency and what the inconsistency is.

Box 3.13 Additional analysis and/or compensatory measures

If there is any conflict with the other safety case requirements, an optioneering is required to determine how to deal with the conflict. The possible main solutions include additional deterministic safety analysis, compensatory measures, SSC design change. Compensatory measures may include corresponding preventive or alternative measures, predetermined

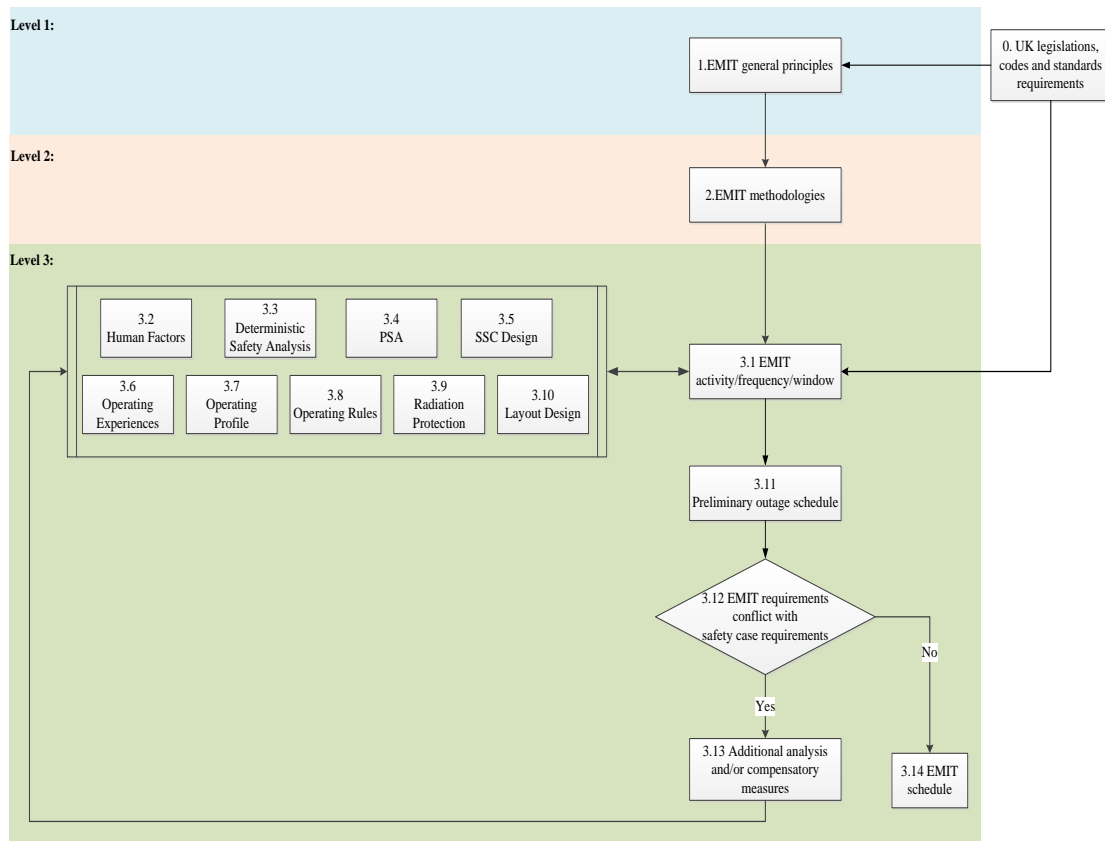
 <p>REGULATORY OBSERVATION RESOLUTION PLAN RO-UKHPR1000-0021</p>	Rev.: 0	Page: 6 / 11
	GDA/REC/GNS/005378	

operating limits and conditions, limited durations, and they are identified as operating rules in Operating Technical Specifications in the site licensing phase. In this stage, *EMIT Strategy Implementation Report* will be produced to present a summary of optioneering process and status of EMIT strategy implementation during GDA.

Box 3.14 EMIT Schedule

After the EMIT requirements are validated consistent within safety case, the detailed EMIT schedule is defined during site licensing phase.

- d) EMIT documentations hierarchy will be introduced as a whole map of EMIT arrangements to explain what kinds of documentations are produced within safety cases.
- e) In *Scope for UK HPR1000 GDA Project* [6], RP has proposed the GDA scope for EMIT. The level 1 and level 2 reports are provided during GDA. For level 3, the class 1 systems and their support systems are sampled to demonstrate that the EMIT principles and methodologies can be achieved and de-risk the potential significant design changes during site licensing phase. The detail of EMIT programmes, procedures and schedule for all systems will be developed according to the EMIT principle and methodology in site licensing phase.



F-1 EMIT design process

RO-UKHPR1000-0021.A2 - Demonstration that the UK HPR1000 design and safety case is compatible with the EMIT Strategy

The RO action 2 states that:

 <p>REGULATORY OBSERVATION RESOLUTION PLAN RO-UKHPR1000-0021</p>	Rev.: 0	Page: 7 / 11
	GDA/REC/GNS/005378	

In response to this Regulatory Observation Action, RP should:

- a) *Provide sufficient information to demonstrate that the UK HPR1000 generic safety case is consistent with the EMIT strategy produced in response to Action 1. The response should provide a proportionate response for key aspects. ONR considers that the response to this Action should include a demonstration that:*
 - *Redundancy, availability and reliability requirements will be derived from and reflected in the safety analysis. This should include both probabilistic and deterministic analysis and take account of relevant regulatory expectations.*
 - *Identified EMIT is consistent with engineering requirements for the SSCs, and vice versa.*
 - *Appropriate codes and standards are used to inform the EMIT.*
 - *The PSA has included explicit consideration of EMIT, and how the component reliability information has been informed by EMIT.*
 - *EMIT has influenced the design or layout of SSCs important to safety, where necessary.*
 - *Identified operating rules take account of EMIT.*
- b) *Provide a suitable and sufficient forward work plan to fully implement the relevant aspects of the EMIT strategy (produced in response to Action 1) into the generic safety case during GDA. This may also need to capture any topic specific aspects, as necessary.*
- c) *Provide evidence that EMIT, including that identified to be taken forward by a future licensee as part of site specific stages, is appropriately captured as part of the generic safety case.*

Resolution Plan Action 2

Based on the strategy in Action 1, the RP will produce a report *Examination, Maintenance, Inspection and Testing (EMIT) Windows* to present EMIT requirements consistent with the assumptions in deterministic safety analysis. This report includes the following information:

- a) The analysis scope of systems is safety systems required in fault schedule.
- b) Operating modes when a safety function (specific trains or key components) is not required in deterministic safety analysis.
- c) The fault schedule V1 as well as system design information which includes redundancy and availability requirements, are used as main input of EMIT Windows. Table 1 is an example to show what EMIT window is.

Table 1 Example of EMIT windows

Systems and components	Reactor in Power	NS/SG	NS/RIS-RHR	MCS	RCS	RCD
XXX pump	no	no	no	yes	yes	yes
XXX train A	no	no	no	yes	yes	yes
XXX train B	no	no	no	yes	yes	yes
...						

In addition, the EMIT activities and frequencies are provided appropriately in *Periodic Test Completeness Note (PTCN)*, *Pre-service inspection list*, and *System Design Manual*, as well as *Strategy of Electrical Power System EMIT* and *Periodic Test Requirement of Protection System (PS)*. They will be updated as necessary after EMIT strategy and methodology is issued.

 General Nuclear System	REGULATORY OBSERVATION RESOLUTION PLAN RO-UKHPR1000-0021	Rev.: 0	Page: 8 / 11
GDA/REC/GNS/005378			

The PSA model have been already submitted, and the unavailability of some frontline systems due to test has been considered. The RP will update the *Internal Events Level 1 PSA*, *Spent Fuel Pool Level 1 PSA* and *Level 2 PSA* reports to include explicit consideration and explanation of EMIT in PSA model. The updated PSA model will:

- a) Assume that the frequency level of test and maintenance of all the systems and components modelled in PSA reach the international average level.
- b) Model the unavailability of the systems considered in PSA due to test and maintenance in train level.

RP will also include relevant information in *EMIT windows* in the planned update of deterministic safety analysis to keep consistency.

After that, the RP provides a report *Preliminary Outage Schedule* for one fuel cycle, which is developed from FCG3 and takes UK requirements, to demonstrate that the EMIT can be achieved.

Furthermore, *EMIT Consistency Analysis* is provided to check whether EMIT requirements are consistent within safety case for UK HPR1000. This report will:

- a) Review the UK requirements to check whether there is any gap for UK HPR1000;
- b) Identify any inconsistency between EMIT and other safety case requirements;
- c) Analyse the impact of the gap or inconsistency (if there is any) to EMIT safety case and identify impacted documentations within safety case.
- d) Clarify the ways to bridge gap or eliminate inconsistency.

At last, the RP will produce an *EMIT Strategy Implementation Report* to provide confidence that the principles outlined in the *Examination, Maintenance, Inspection and Testing (EMIT) Strategy* have been effectively adopted in the design. This report will:

- a) Update the status of the EMIT document production. This includes a list of the reports which are impacted by *Examination, Maintenance, Inspection and Testing (EMIT) Strategy* to make sure that EMIT requirements are adequately embedded in the UK HPR1000 generic safety case;
- b) Present the option evaluation when EMIT inconsistency is identified in the consistency analysis.
- c) Provide a review of *Examination, Maintenance, Inspection and Testing (EMIT) Strategy* to ensure fully implementation of the relevant aspects of the *Examination, Maintenance, Inspection and Testing (EMIT) Strategy* into the generic safety case according to UK HPR1000 project status.
- d) Provide confidence that the *Examination, Maintenance, Inspection and Testing (EMIT) Strategy* has been adopted, that EMIT requirements are embedded within the design process, and that there is an appropriate iteration between safety analysis and EMIT requirements. The level of detail is commensurate with the design detail available during GDA and the level of maturity of EMIT as defined in the *Examination, Maintenance, Inspection and Testing (EMIT) Strategy*.

The impact from EMIT tasks mentioned above will be reflected in planed update of *UK HPR1000 Fault Schedule* version 2, and then *Examination, Maintenance, Inspection and Testing (EMIT) Windows* will be updated if needed in December 2020.

 CGN EDF General Nuclear System	REGULATORY OBSERVATION RESOLUTION PLAN RO-UKHPR1000-0021	Rev.: 0	Page: 9 / 11
		GDA/REC/GNS/005378	


Considering the Requirements Management work being carried out in response to RO-UKHPR1000-0004 Action 4 (4-1 Requirements Identification and Capture Process, 4-3 Requirements Transition Plan General Nuclear System Limited to BRB), the RP believes this approach will satisfy the requirements of Action 2.

Table 2 presents the link between ONR expectations and RP response to get an easy understanding.

Table 2 The link between ONR expectations and RP response

No.	ONR expectation	RP respond/Report
1	EMIT scope	Examination, Maintenance, Inspection and Testing (EMIT) Strategy
2	UK legal requirements	Examination, Maintenance, Inspection and Testing (EMIT) Strategy EMIT Consistency Analysis
3	Deliver to operating rules	Examination, Maintenance, Inspection and Testing (EMIT) Strategy
	Compatible with engineering requirements	EMIT Consistency Analysis
	Consistent with safety analysis	Examination, Maintenance, Inspection and Testing (EMIT) Windows EMIT Consistency Analysis EMIT Implementation Report Internal Events Level 1 PSA Spent Fuel Pool Level 1 PSA and Level 2 PSA UK HPR1000 Fault Schedule V2
	Consistent with reliability claims	Internal Events Level 1 PSA Preliminary Outage Schedule
4	EMIT documentations	Examination, Maintenance, Inspection and Testing (EMIT) Strategy

Impact on the GDA Submissions

 General Nuclear System	REGULATORY OBSERVATION RESOLUTION PLAN RO-UKHPR1000-0021	Rev.: 0	Page: 10 / 11
		GDA/REC/GNS/005378	

The information will be incorporated into PCSR Chapter 12, 13 and 31 v1/v2 submitted in the step 3 and step 4. Related PCSR Chapters and their supporting submissions are also involved in this resolution plan.

GDA Submission Document	Related ROAs	Planned schedule for submission
Preventive Maintenance Programme Principle (preliminary)	ROA1	2019.11
Examination, Maintenance, Inspection and Testing (EMIT) Strategy	ROA1	2020.01
Examination, Maintenance, Inspection and Testing (EMIT) Windows	ROA2	2020.03
Preliminary outage schedule	ROA2	2020.06
EMIT Consistency Analysis	ROA2	2020.07
EMIT Strategy Implementation Report	ROA2	2020.12
Updating existing documentation where appropriate	ROA2	2020.12

Timetable and Milestone Programme Leading to the Deliverables


See attached Gantt Chart in APPENDIX A.

References

- [1] ONR, Safety Assessment Principles for Nuclear Facilities, Rev. 0, November 2014.
- [2] Pre-Construction Safety Report, Chapter 31 Operational Management, HPR/GDA/PCSR/0031, Revision 000, November 2018.
- [3] Periodic Test Design Methodology, NE15BWXYX0000000021, Rev. B, 2018
- [4] Outline of PSI and ISI Requirements for UK HPR1000, GHX10000330DPCH01GN, Rev. A, 2019.
- [5] Periodic Test Requirement of Protection System (PS), GHX06002017DIYK03GN, Rev. A, 2019
- [6] Scope for UK HPR1000 GDA Project, HPR-GDA-REPO-007, Rev.001, 2019

PREVIOUS REVISIONS RECORD

Rev.	Author	Scope/Reason of Revision	Date	Page

	REGULATORY OBSERVATION RESOLUTION PLAN RO-UKHPR1000-0021	Rev.: 0	Page: 11 / 11
		GDA/REC/GNS/005378	

APPENDIX A RO-UKHPR1000-0006 Gantt Chart

