REGULATORY OBSERVATION

REGULATOR TO COMPLETE

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Revision:	0
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Acknowledgement required by:	26/06/18
Agreement of Resolution Plan Required by:	29/06/18
TRIM Ref:	2018/186491
Related RQ / RO No. and TRIM Ref: (if any)**:**	
Observation title:	Suitable and Sufficient Severe Accident Analysis Safety Case
Lead technical topic: 19. Severe Accident Analysis	**Related technical topic(s):** 9. Fault Studies 15. Probabilistic Safety Analysis

Regulatory Observation

Background

ONR's guidance (Safety Assessment Principles (SAPs)) requires that "*Fault analysis should be carried out comprising suitable and sufficient design basis analysis, PSA and severe accident analysis (SAA) to demonstrate that risks are as low as reasonably practicable (ALARP)*" (Ref. 1). Therefore, ONR expect that fault sequences beyond the design basis, that have the potential to lead to a severe accident, should be analysed. The SAA should provide information:

- to assist in the identification of any further reasonably practicable preventative or mitigating measures beyond those derived from the design basis
- to assist in the demonstrate that the severe accident safety measures are adequately engineered and can be substantiated
- to demonstrate that the level of risk is ALARP
- to form a suitable basis for accident management strategies
- to support the preparation of emergency plans for the protection of people
- to determine the magnitude and characteristics of radiological consequences
- to support the probabilistic safety analyses (PSA) of the facility's design and operation.

ONR requires a structured and systematic safety case for the UK HPR1000 in the area of SAA to demonstrate that these requirements, and most significantly the ALARP principle, are met.

ONR has assessed Chapter 13 of the Preliminary Safety Report (PSR), Design Extension Conditions and Severe Accident Analysis – HPR/GDA/PSA/0013 (Ref. 2). From this, it is clear that the HPR1000 reference design has considered Severe Accidents and includes a number of specific severe accident mitigation features. However, in addition to assessment of Chapter 13 of the PSR, recent Level 4 engagements with GNS (Ref. 3) have indicated that there is a significant gap between ONR expectations and the current approach and intentions for the UK HPR1000 SAA safety case proposed by GNS during GDA, both in terms of the content and timing. At present, a program to complete a structured and systematic safety case for the SAA for UK HPR1000 is not evident, and moreover, several aspects of the existing approaches adopted do not yet appear to align with UK expectations.

This RO has therefore been raised to ensure that the SAA safety case produced for UK HPR1000 will meet UK regulatory expectations.

Relevant Legislation, Standards and Guidance

The ONR Safety Assessment Principles expect that a safety case should be accurate, objective and demonstrably complete for its intended purpose. A safety case should set out the argument for why risks are ALARP, and to achieve this, a safety case should identify the facility's hazards by a thorough and systematic process.

The requirement for a suitable and sufficient SAA safety case to be provided as part of the GDA is contained in the ONR Guide to Requesting Parties (Ref. 4), Appendix 2. This states that: *"It is important that the information provided in the safety case is suitable and sufficient to demonstrate, in the opinion of ONR, that risks have been reduced so far as is reasonably practicable (SFAIRP)."*

The expectations for a SAA safety case is contained within the ONR SAPs (Ref. 1). The principle SAPs of relevance include:

FA.1:
Fault analysis should be carried out comprising suitable and sufficient design basis analysis, PSA and severe accident analysis to demonstrate that risks are ALARP.
FA.15:
Fault states, scenarios and sequences beyond the design basis that have the potential to lead to a severe accident should be analysed.
FA.16:
Severe accident analysis should be used in the consideration of further risk-reducing measures.

ONR will also consider our guidance on the demonstration of ALARP (Ref. 5), severe accident analysis (Ref. 6) and international guidance in the area of severe accidents, as per the SAA Step 2 Assessment Plan:

Body	Standard Number	Title
ANS/ASME	58.24-2014	Severe Accident Progression and Radiological Release (Level 2) - PRA Methodology to Support Nuclear Installations Applications
	RA-S-1.3	Radiological Accident Offsite Consequence Analysis (Level 3 PRA) to Support Nuclear Installation Applications
IAEA	Safety Guide NS-G-2.15 (2009)	Severe Accident Management Programmes for Nuclear Power Plants
	IAEA Safety Report Series No 56 (2008)	Approaches and Tools for Severe Accident Analysis for Nuclear Power Plants
WENRA	Statement on Safety Objectives for New Nuclear Power Plants (November 2010) - O3.	Accidents with core melt
	Study by Reactor Harmonization Working Group - March 2013	Safety of new NPP designs

Regulatory Expectations

ONR expect that the scope of the SAA safety case produced for UK HPR1000 will include consideration of all significant sources of radioactivity that could lead to a severe accident, all operating modes, the impact of hazards, and include consideration of lessons learnt from past international nuclear accidents. The end point should be once a safe and sustainable position has been reached in the accident, which may include consideration of effects over the longer term.

ONR's expectations are that SAA should be part of the overall safety case produced for UK HPR1000. This should be undertaken in a holistic, systematic and structured manner, as an integral part of the overall safety justification, with the key objective of justifying that risks are reduced ALARP, and that all reasonably practicable measures to reduce that risk have been included within the generic design. The safety case

should also justify that those engineered safety features are capable of delivering their safety functions with the required level of reliability.

As part of responding to this RO, ONR expect to gain confidence that the risks from severe accidents have been analysed through a systematic approach. To achieve this, as part of the resolution of this RO, GNS will need to provide the following:

- A strategy for the SAA program that will provide enough information for ONR to gain confidence that the required work can be performed as necessary during GDA.
- Proposed SAA methodologies/ processes/ procedures (including any assumptions) which GNS will use to evaluate the SAA sequences, including non-reactor sequences such as the SFP
- A demonstration that the SAA strategy and SAA methodology will result in a complete SAA safety in timescales compatible with the GDA process.
- A complete list of the claims for the severe accident engineered features, and a demonstration that a systematic approach has been taken to understand and justify that the proposed safety functions of these systems can be met. This should include information on human operation performance during SAA sequences.

The Regulatory Observation Actions (ROAs) given below are therefore structured in such a way as to enable provision of this information in a logical and step-wise manner, to facilitate ONR's assessment as the GDA progresses.

References

1) Safety Assessment Principles for Nuclear Facilities, 2014 Edition, Revision 0, ONR, November 2014
2) Preliminary Safety Report, Chapter 13, Design Extension Conditions and Severe Accident Analysis, HPR/GDA/PSR/0013, Revision 000, General Nuclear System Ltd. October 2017
3) UK HPR1000 GDA Step 2 – SAA Level 4 Meeting – February 2018 (Trim Ref. 2018/55310)
4) ONR-GDA-GD-001 Revision 3, New nuclear reactors: Generic Design Assessment Guidance to Requesting Parties, September 2016
5) ONR-NS-TAST-GD-005 Revision 6, Demonstration of ALARP
6) ONR-NS-TAST-GD-007 Revision 3, Severe Accident Analysis

Regulatory Observation Actions

RO-UKHPR1000-0003.A1 – SAA Strategy

In response to this Regulatory Observation Action, GNS should provide their strategy for the completion of a suitable and sufficient SAA safety case during GDA.

This strategy should clearly identify "what" activities GNS intend to undertake to provide the SAA safety case for UK HPR1000.

ONR would expect this to, amongst other relevent matters:

- Provide the objectives for the SAA
- Identify the Relevant Good Practice (RGP) considered by GNS, including learning from the fukushima accident and the Vienna declaration
- Provide a justification for how GNS intend to demonstrate compliance with UK regulatory expectations and international RGP. This should include how GNS plans to show that the SAA has been used to:
  - Identify any further reasonably practicable preventative or mitigating measures;
  - Form a suitable basis for accident management strategies;
  - Support the preparation of emergency plans for the protection of people;
  - Determine the magnitude and characteristics of radiological consequences;
  - Support the PSA of the facility's design and operation; and
  - Demonstrate adequate understanding of the severe accident phenomena and accident progression.
- Provide information on how a coherent safety case for UK HPR1000 will be produced
- Define the scope and objectives of the intended radiological consequence analysis
- Identify the criteria used for SAA against which the performance of the engineered features,

strategies and procedures can be judged
- Define the scope of the severe accident safety case for GDA (i.e. emergency procedures, SAMGs, SBERGs, etc.). If assumptions are made on the future Licensee's emergency capabilities or procedures these should be clearly stated.
- Provide a clear detailed outline of work that is required to produce a SAA safety case for UK HPR1000. This should be with accurate dating for Step 2 of the GDA, and with approximate dating for Step 3.

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-UKHPR1000-0003.A2 – SAA Methodology

In response to this Regulatory Observation Action, GNS should provide the methodology for all aspects of the technical work that is required to be performed for the SAA.

This methodology should clearly identify "how" GNS intend to undertake the activities identified in Response to Action 1, in order to provide the SAA safety case for UK HPR1000.

ONR would expect that this methodology will cover the full scope of SAA and include topics such as:

- A description of the overall strategy to deal with severe accidents at a UK HPR1000, that will serve as the basis for the development of severe accident management guidelines and which should be underpinned by severe accident analysis
- A description of the computer codes used, their purpose and and an outline for how the verification and validation information on the relevant computer codes will be provided
- information on the uses of these computer codes in the analysis of SAA sequences
- Comprehensive list and description of all relevant severe accident phenomena including a justification of any known severe accident phenomena that have been excluded from consideration
- Comprehensive list and description of possible release paths and the behaviour of radionuclides for the UK HPR1000, including:
  - Claims on fission products to be retained within the containment and a description of the behaviour of radionuclides (in-vessel and ex-vessel) following a severe accident.
  - A description of the containment failure mode/s assumed in the analyses.
  - A description of all other possible release paths following a severe accident considered for the UK HPR1000
- A description of the optioneering process which has been, or will be, done to consider what severe accident design measures are reasonably practicable for the UK HPR1000. This should include how GNS will justify that the design of the UK HPR1000 represents RGP and follows the ALARP principle in relation to severe accident engineered measures.

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-UKHPR1000-0003.A3 – Demonstration of the Adequacy of the SAA Safety Case

In response to this Regulatory Observation Action, GNS should provide sufficient evidence of the various outputs of the work items described in response to Actions 1 and 2 above, to demonstrate that an adequate safety case for SAA will be provided during GDA.

The nature of this demonstration should be defined by GNS, based upon the response to Actions 1 and 2, but this may be in the form of a safety case for a single SAA sequence analysis or by providing elements from different sequences along with a description of how they fit into the overall safety case. However, ONR expect that collectively, sufficient information should be provided for ONR to satisfy itself that regulatory expecations are likley to be met for GDA.

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

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RO-UKHPR1000-0003.A4 – Demonstration of the Adequacy of the SAA Engineered Features

In response to this Regulatory Observation Action, GNS should demonstrate that a systematic approach has been taken to the identification of safety functions for SAA and that the list of claims made on the severe accident engineered measures (including human actions) is complete.

ONR anticipates that this demonstration will require the provision of detailed information on the design features and their importance to the severe accident management strategies, for example:

- The number, type, and location of electrical and mechanical connection.
- SAA system safety classification and withstand capability on all of the proposed severe accident engineered features.
- Description of Fukushima related improvements (for example, backup building, mobile components, hydrogen management etc.).
- Description of the measures for hydrogen management (and other combustible gases) during a severe accident. This should include addressing the possibility of hydrogen leakage out of the containment building into the spent fuel building, safeguard buildings, etc.
- Information on the systems and strategies to control the containment pressure following a severe accident (for example, strategy, system design and filter design).
- Details of the strategy and approach for containing a molten core debris (for example, strategy, system design and requirements)
- The response to this action should include the outputs from the consideration of optioneering for topics such as:
  - methods / technologies for confining a molten core,
  - passive methods of core or containment cooling,
  - methods for further increasing grace / response times,
  - methods of further capturing / reducing fission products inside containment,
  - passive methods for flammable gas control.

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:	