

**New Reactor Division – Generic Design Assessment
Step 2 Assessment of the Conventional Fire Safety of UK HPR1000 Reactor**

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EXECUTIVE SUMMARY

This report presents the results of my Conventional Fire Safety assessment of the UK HPR1000 undertaken as part of Step 2 of the Office for Nuclear Regulation's (ONR) Generic Design Assessment (GDA).

The GDA process calls for a step-wise assessment of the Requesting Party's (RP) safety submission with the assessments increasing in detail as the project progresses. Step 2 of GDA is an overview of the acceptability, in accordance with the regulatory regime of Great Britain, of the design fundamentals, including ONR's review of key nuclear safety and nuclear security claims (or assertions). The aim is to identify any fundamental safety or security shortfalls that could prevent ONR from permitting the construction of a power station based on the design.

During GDA Step 2 my work has focused on the assessment of the Conventional Fire Safety aspects within the UK HPR1000 Preliminary Safety Report (PSR), and a number of supplementary documents submitted by the RP, focusing on design concepts and claims.

The standards I have used to judge the adequacy of the RP's submissions in the area Conventional Fire Safety have been primarily published guidance for Fire Safety in the design and management of buildings in the UK. This guidance includes; Approved Document 'B' to the Building Regulations (Ref. 1); British Standard 9999: 2017, the Code of Practice for Fire Safety in the Design Management and Use of Buildings (Ref. 2); and British Standard 7974; - Application of fire safety engineering principles to the design of buildings (Ref. 3).

My GDA Step 2 assessment work has involved regular engagement with the RP in the form of technical exchange workshops and progress meetings, including meetings with the plant designers.

The UK HPR1000 PSR is primarily based on the Reference Design, Fangchenggang Unit 3 (FCG3), which is currently under construction in China. Key aspects of the UK HPR1000 preliminary safety case related to Conventional Fire Safety, as presented in the PSR, its supporting references and the supplementary documents submitted by the RP, can be summarised as follows:

- The PSR contains objectives which provide confidence that fire safety for the protection of people from the danger of fire will be adequately assessed, and risks reduced ALARP during the progress of the UK HPR1000 through the GDA process. Relevant objectives include;
 - The PSR identifies fire as a risk to life safety.
 - The principle of defence in depth is applied to fire protection arrangements.
 - There is an objective to "*Eliminate or reduce risk*".
 - There is recognition by the RP of the need to map the design against UK regulations for Conventional Fire Safety and determine a gap analysis.

During my GDA Step 2 assessment of the UK HPR1000 aspects of the safety claims related to Conventional Fire Safety I have identified the following areas of strength:

- The RP produced a high level fire safety strategy which describes how the design of the UK HPR1000 will comply with legislative requirements and meet UK expectations for fire safety in the design of buildings to protect people from the danger of fire.
- A procedure has been developed, to identify those areas where the design departs from published guidance, and to consistently manage the 'gaps' in compliance with prescriptive codes of practice. The management process utilises fire engineering

principles to provide an adequate level of safety which is achieved by implementing alternative fire protection measures to reduce fire risks in the final design ALARP.

During my GDA Step 2 assessment of the UK HPR1000 aspects of the safety claims related to Conventional Fire Safety I have identified the following area that requires follow-up:

- The “Methodology for Gap Management in Conventional Fire Safety Area revision C, GH X 40300 005 DOZJ 03 GN” (Ref. 4); - will remain a live document during Step 3 and will require regular updates from lessons learnt, after the RP benchmark the fire engineered design solutions against relevant good practice.

During my GDA Step 2 assessment, I have not identified any fundamental safety shortfalls in the area of Conventional Fire Safety that might prevent the issue of a Design Acceptance Confirmation (DAC) for the UK HPR1000 design.

LIST OF ABBREVIATIONS

ALARP	As Low As Reasonably Practicable
BAT	Best Available Technique
BS	British Standard
BSL	Basic Safety Level (in SAPs)
BSO	Basic Safety Objective (in SAPs)
CGN	China General Nuclear Power Corporation
DAC	Design Acceptance Confirmation
EA	Environment Agency
EDF	Électricité de France
FCG3	Fangchenggang Unit 3
GNI	General Nuclear International
GNS	Generic Nuclear System Ltd
GSR	Generic Security Report
IAEA	International Atomic Energy Agency
JPO	(Regulators') Joint Programme Office
NPP	Nuclear Power Plant
ONR	Office for Nuclear Regulation
PCER	Pre-construction Environmental Report
PCSR	Pre-construction Safety Report
PSR	Preliminary Safety Report (includes security and environment)
RGP	Relevant Good Practice
RHWG	Reactor Harmonization Working Group (of WENRA)
RI	Regulatory Issue
RIA	Regulatory Issue Action
RO	Regulatory Observation
ROA	Regulatory Observation Action
RP	Requesting Party
RQ	Regulatory Query

SAP(s)	Safety Assessment Principle(s)
SFAIRP	So far as is reasonably practicable
TAG	Technical Assessment Guide(s)
TSC	Technical Support Contractor
TSF	Technical Support Framework
WENRA	Western European Nuclear Regulators' Association

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1 INTRODUCTION

1. The Office for Nuclear Regulation's (ONR) Generic Design Assessment (GDA) process calls for a step-wise assessment of the Requesting Party's (RP) safety submission with the assessments increasing in detail as the project progresses. General Nuclear System Ltd (GNS) has been established to act on behalf of the three joint requesting parties (China General Nuclear Power Corporation (CGN), Électricité de France (EDF) and General Nuclear International (GNI)) to implement the GDA of the UK HPR1000 reactor. For practical purposes GNS is referred to as the 'UK HPR1000 GDA Requesting Party'.
2. During Step 1 of GDA, which is the preparatory part of the design assessment process, the RP established its project management and technical teams and made arrangements for the GDA of the UK HPR1000 reactor. Also, during Step 1 the RP prepared submissions to be assessed by ONR and the Environment Agency (EA) during Step 2.
3. Step 2 commenced in November 2017. Step 2 of GDA is an overview of the acceptability, in accordance with the regulatory regime of Great Britain, of the design fundamentals, including ONR's assessment of key nuclear safety and nuclear security claims (or assertions). The aim is to identify any fundamental safety or security shortfalls that could prevent ONR permitting the construction of a power station based on the design.
4. My assessment has followed my GDA Step 2 Assessment Plan for Conventional Fire Safety (Ref. 5) which was prepared in October 2017 and shared with GNS to maximise openness and transparency.
5. This report presents the results of my Conventional Fire Safety assessment of the UK HPR1000 as presented in the UK HPR1000 Preliminary Safety Report (PSR) (Ref. 6) and its supporting documentation.

References; -

- Methodology for Gap Management in Conventional Fire Safety Area revision C, Document reference GH X 40300 005 DOZJ 03 GN.
- High Level Fire Safety Strategy revision B, Document reference GH X 40300 004 DOZJ 03 GN (Ref. 7).

2 ASSESSMENT STRATEGY

6. This section presents my strategy for the GDA Step 2 assessment of the Conventional Fire Safety aspects of the UK HPR1000 (ONR-GDA-AP-17-013). It also includes the scope of the assessment and the standards and criteria I have applied.

2.1 Scope of the Step 2 Conventional Fire Safety Assessment

7. The objective of my GDA Step 2 assessment was to assess relevant design concepts and claims made by the RP related to Conventional Fire Safety. In particular, my assessment has focussed on the following:
- Mainly, the structural arrangements to provide means of escape in case of fire and facilities for firefighters.
 - Other fire protection measures, where these are claimed as mitigation to support means of escape.
8. During GDA Step 2 I have also evaluated whether the safety claims related to Conventional Fire Safety are supported by a body of technical documentation sufficient to allow me to proceed with GDA work beyond Step 2.
9. Finally, during Step 2 I have undertaken the following preparatory work for my Step 3 assessment:
- I have provided input during fire safety design workshops and given advice on ONR's expectations for Step 3 including guidance on how to maximise the benefit of the workshop approach in fire engineering issues.
 - I have reviewed the proposed delivery schedule of Fire Strategy documents and advised that an alternative approach is necessary in order to de-risk the project and meet the requirements of the GDA process. The RP was advised to conduct an initial assessment of the HPR1000 for compliance with targeted areas within UK codes of practice for fire safety in the design of buildings and present ONR with a delivery schedule based upon a risk assessed methodology. Submission of fire strategies is expected to prioritise those facilities with the most challenging means of escape arrangements which have greatest potential to require structural redesign to achieve an ALARP position.

2.2 Standards and Criteria

10. For ONR, the primary goal of the GDA Step 2 assessment is to reach an independent and informed judgment on the adequacy of the building design and fire protection measures. Assessment was undertaken in accordance with the requirements of the Office for Nuclear Regulation (ONR) How2 Business Management System (BMS) guide NS-PER-GD-014 (Ref. 8).
11. Assessment was undertaken against legislative fire safety design requirements, established national standards and published relevant industry good practice.
12. Furthermore, ONR is a member of the Western European Regulators Nuclear Association (WENRA). WENRA has developed Reference Levels, which represent good practices for existing nuclear power plants, and Safety Objectives for new reactors.

2.2.1 National and International Standards and Guidance

13. The following national and international standards and guidance have been considered as part of this assessment:
- Legislative requirements of:-

- Regulatory Reform (Fire Safety) Order 2005. (Ref. 9)
- Construction (Design and Management) Regulations 2015. (Ref. 10)
- Relevant UK standards for fire safety in building design and management
 - Approved Document 'B' Fire Safety to the Building Regulations 2010
 - British Standard 9999: 2017 Code of Practice for Fire Safety in the design, management and use of buildings.
 - British Standard 7974: Code of practice for the application of fire safety engineering principles to the design of buildings.
- Published Fire Safety Guidance and Relevant Good Practice.
 - British Standard 5839: Code of practice for fire detection and alarm systems for buildings. (Ref. 11)

2.3 Use of Technical Support Contractors

14. During Step 2 I have not engaged Technical Support Contractors (TSCs) to support the assessment of the Area Name for the UK HPR1000.

2.4 Integration with Other Assessment Topics

15. Early in GDA, I recognised the importance of working closely with other inspectors (including Environment Agency's assessors) as part of the Conventional Fire Safety assessment process. Similarly, other inspectors sought input from my assessment of the Conventional Fire Safety for the UK HPR1000. I consider these interactions are key to the success of the project in order to prevent or mitigate any gaps, duplications or inconsistencies in ONR's assessment. From the start of the project, I have endeavoured to identify potential interactions between the Fire Safety and other technical areas, with the understanding that this position will evolve throughout the UK HPR1000 GDA.
16. The key interactions I have identified are:
- Security provides input to the means of escape aspects of the Conventional Fire Safety assessment. This formal interaction has not commenced during GDA Step 2. This work is being / will be by the Security Inspector.

3 REQUESTING PARTY'S SAFETY CASE

17. During Step 2 of GDA the RP submitted a PSR and other supporting references, which outline a preliminary nuclear safety case for the UK HPR1000. This section presents a summary of the RP's preliminary safety claims in the area of Conventional Fire Safety. It also identifies the documents submitted by the RP which have formed the basis of my Conventional Fire Safety assessment of the UK HPR1000 during GDA Step 2.

3.1 Summary of the RP's Preliminary Safety Case in the Area of Conventional Fire Safety

18. The aspects covered by the UK HPR1000 preliminary safety case in the area of Conventional Fire Safety are contained within Preliminary Safety Report, Chapter 25, Conventional Safety; Document Reference HPR/GDA/PSR/0025.

19. The PSR contains objectives which provide confidence that fire safety for the protection of people from the danger of fire will be adequately assessed, and risks reduced ALARP during the progress of the UK HPR1000 through the GDA process. Relevant objectives include;

- The PSR identifies fire as a risk to life safety.
- The principle of defence in depth is applied to fire protection arrangements
- There is an objective to "*Eliminate or reduce risk*".
- There is recognition by the RP of the need to map the design against UK regulations for Conventional Fire Safety and determine a gap analysis.

3.2 Basis of Assessment: RP's Documentation

20. The RP's documentation that has formed the basis for my GDA Step 2 assessment of the safety claims related to the Conventional Fire Safety aspects of the UK HPR1000 is presented in

- Preliminary Safety Report, Chapter 25, Conventional Safety, This report details the policy of the RP to assess the areas of the design against UK requirements and to produce a nuclear power plant which is safe to build and operate.
- High Level Fire Safety Strategy revision B; - GH X 40300 004 DOZJ 03 GN. The Strategy document describes, at a high level, how the RP will meet the requirements UK fire safety legislation and describes how the design will address UK expectations for fire safety in buildings to provide suitable arrangements for the protection people from the danger of fire. The document explains the intention to produce detailed fire safety analysis of individual facilities, as the GDA process develops.
- Methodology for Gap Management in Conventional Fire Safety Area revision C; - GH X 40300 005 DOZJ 03 GN. This document details a procedure to consistently identify and manage all instances where the design of a facility departs from the recommended guidance in the prescriptive codes of practice for the protection of life safety from the danger of fire. These 'gaps' arise due to the need to fulfil the function of a nuclear power plant and the Methodology describes how an adequate level of safety will be achieved using alternative, fire engineered arrangements.

21. In addition, during April 2018 the RP submitted to ONR, for information, an advance copy of the UK HPR1000 Pre-Construction Safety Report (PCSR). Chapter 25, (Ref. 12), addresses Conventional Fire Safety. Having early visibility of the scope and content of this chapter/s has been useful in the planning and preparation of my GDA Step 3 assessment work

4 ONR ASSESSMENT

22. This assessment has been carried out in accordance with HOW2 guide NS-PER-GD-014, "Purpose and Scope of Permissioning".
23. My Step 2 assessment work has involved regular engagement with the RP's Conventional Fire Safety specialists, including attending two Technical Exchange Workshops in the UK.
24. During my GDA Step 2 assessment, I have identified some gaps in the documentation formally submitted to ONR. Consistent with ONR's Guidance to Requesting Parties these normally lead to Regulatory Queries (RQs) being issued. At the time of writing my assessment report, in Conventional Fire Safety, during Step 2, I have raised, RQ-UKHPR1000-0144 (Ref. 13), to facilitate my assessment.
25. Details of my GDA Step 2 assessment of the UK HPR1000 preliminary safety case in the area of Conventional Fire Safety, including the conclusions I have reached, are presented in the following sub-sections of the report. This includes the areas of strength I have identified, as well as the items that require follow-up during subsequent steps of the GDA of UK HPR1000.

4.1 Assessment

4.1.1 Conventional Fire Safety

26. My Step 2 assessment involved a review of the RP's safety submission/s to confirm whether the claims related to Conventional Fire Safety in the design of the building, adequately meet UK expectations for the protection of people from the danger of fire.
27. I considered the RP submissions against UK Safety Legislation to assess if the proposals would satisfy the structural fire safety requirements of the Regulatory Reform (Fire Safety) Order 2005; The Construction Design and Management Regulations 2015; Building Regulations, (Ref. 14) and the Health & Safety at Work etc Act, 1974 (Ref. 15). In particular, I assessed the RP's documents to confirm that the RP was aware of the interdependencies between these individual items of legislation to act together to require adequate arrangements to protect people from fire.
28. The High Level Fire Safety Strategy document indicates that the RP can produce a design which satisfies UK legal requirements for fire safety in building design. Where the design varies from British Standard 9999 the RP's Management of Gaps document will be applied to each case, to ensure adequate fire safety is provided for the occupants by the use of alternative, fire engineered, arrangements.
29. I assessed the Management of Gaps document to ensure the process would effectively identify departures from compliance with prescriptive guidance, prioritise the life risk arising from the gap and produce a design solution where risks reduced ALARP.
30. I found that the RP identified all relevant legislation, appropriate building design guidance, relevant industry good practice and demonstrated a clear understanding that fire risk management needs to be considered consistently across all areas to ensure that risk is reduced As Low as Reasonably Practicable (ALARP).
31. I considered whether claims related to Conventional Fire Safety are supported by a body of detailed technical documentation sufficient to allow ONR to proceed with GDA work beyond Step 2 (noting that in depth examination of the detailed arguments and evidence that support the claims will be undertaken in my assessment during Steps 3 and 4 of GDA).

32. Beyond Step 2, the RP will assess the design against the appropriate codes of practice for fire safety in building design and demonstrate that appropriate arrangements are in place to protect people from the danger of fire within the buildings. The methodology within the procedure broadly follows the principles of British Standard 7974 and employs relevant good practice in providing an ALARP justification for the selected fire protection arrangements.
33. I consider the management procedures described by the RP in the Management of Gaps document to be robust and suitable for purpose. The procedure includes a method for consistent identification of departures and prioritisation of the safety gap. Optioneering of alternative fire engineered arrangements is proposed and the selected option(s) will be supported by an ALARP justification. These principles conform to the fire engineering principles contained within British Standard 7974, and comply with industry relevant good practice for fire engineering design.

4.1.2 Strengths

34. In order to fulfil the function of a nuclear power plant it is necessary, in some areas, to depart from recognised codes of practice in fire safe design for conventional premises. The RP has recognised the need to balance the safety and security needs across a wide range of subject matter disciplines and have produced a document describing the management procedure to adequately address issues whilst ensuring a holistic ALARP position is achieved. The document "Methodology for Gap Management in Conventional Fire Safety Area" employs industry best practice for maintaining fire safety through the application of fire engineering principles.

4.1.3 Items that Require Follow-up

35. During my GDA Step 2 assessment of "Conventional Fire Safety" I have identified the following specific shortfall:
- The "Methodology for Gap Management in Conventional Fire Safety Area revision C, will remain a live document during Step 3 and will require regular updates from lessons learnt, after GNS benchmark their fire engineered design solutions against relevant good practice.

4.1.4 Conclusions

36. Based on the outcome of my Step 2 assessment of "Conventional Fire Safety", I have concluded that the RP has provided sufficient for me to conduct a meaningful Step 2 assessment.

4.2 ALARP Considerations

4.2.1 Assessment

37. The ALARP Methodology document provided by the RP (Ref. 16) adequately describes the principles to be employed to reduce risks as low as reasonably practicable.

4.2.2 Strengths

38. The RP proposes to follow Industry good practice in the application of the ALARP principles. The document will be particularly useful when there are competing requirements from differing safety disciplines and will help to support a truly holistic ALARP position.

4.2.3 Items that Require Follow-up

39. I will further consider the application of the RP's ALARP methodology in later GDA Steps.

4.2.4 Conclusions

40. A robust ALARP justification of the fire engineered arrangements to protect people from the danger of fire is a key component of the Management of Gaps document and the detail and processes contained in the ALARP Methodology document, will provide useful support and guidance for the RP's Engineers.

4.3 Out of Scope Items

41. I have not identified any items as outside the scope of my GDA Step 2 assessment of the UK HPR1000 Conventional Fire Safety.

4.4 Comparison with Standards, Guidance and Relevant Good Practice

42. In Section 2.2, above, I have listed the standards and criteria I have used during my GDA Step 2 assessment of the UK UKHPR1000 Conventional Fire Safety, to judge the adequacy of the preliminary safety case. In this regard, my overall conclusions can be summarised as follows:

- The RP has demonstrated adequate understanding of UK legislative requirements to reduce the risk to people from the danger of fire as low as reasonably practicable.
- The RP has adequate arrangements in place to review the HPR1000 against appropriate building design codes of practice to meet UK expectations for fire safety in the design and management of buildings.
- Where departures from compliance with published guidance are necessary, to meet the objectives and safety requirements of a nuclear power plant, the RP have developed a suitable procedure to manage 'Gaps' and identify alternative fire engineered ALARP design solutions

4.5 Interactions with Other Regulators

43. I have not required interaction with other regulators at this stage of the GDA process.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

44. During Step 2 of GDA, the RP submitted a PSR and other supporting references, which outline a preliminary nuclear safety case for the UK HPR1000. These documents have been formally assessed by ONR. The PSR together with its supporting references present at a high level, the claims in the area of Conventional Fire Safety that underpin the safety of the UK HPR1000.
45. During Step 2 of GDA I have targeted my assessment at the content of the PSR and its references that is of most relevance to the area of Conventional Fire Safety; against UK legal requirements for the protection of people from the danger of fire and relevant good practice in the design and management of buildings for fire safety. From the UK HPR1000 assessment done so far, I conclude the following:
- The High Level Fire Safety Strategy document confirms that the RP can produce a design which satisfies UK legal requirements for fire safety in building design.
 - Where departures from compliance with fire safety design guidance are necessary, to meet the objectives and safety requirements of a nuclear power plant, the RP has developed a suitable procedure within Methodology for Gap Management in Conventional Fire Safety Area to manage safety gaps and identify alternative fire engineered ALARP design solutions.
 - The RP has provided evidence within the PCSR, High Level Fire Safety Strategy and Methodology for Gap Management that the RP can design a nuclear power plant that meets UK expectations for the protection of people from the danger of fire.
46. Overall, during my GDA Step 2 assessment, I have not identified any fundamental safety / security shortfalls in the area of Conventional Fire Safety that might prevent the issue of a Design Acceptance Confirmation (DAC) for the UK HPR1000 design.

5.2 Recommendations

47. My recommendations are as follows.
- Recommendation 1: ONR should consider the findings of my assessment in deciding whether to proceed to Step 3 of GDA for the UK HPR1000.
 - Recommendation 2: All the items identified in Step 2 as important to be followed up should be included in ONR's GDA Step 3 Conventional Fire Safety Assessment Plan for the UK HPR1000.

6 REFERENCES

1. Approved Document 'B' Fire Safety to the Building Regulations: 2010; ISBN 978-1-85946-489-2.
2. British Standard 9999: 2017 Code of Practice for Fire Safety in the design, management and use of buildings.
3. British Standard 7974:2001 - Application of fire safety engineering principles to the design of buildings. Code of practice ISBN 0 580 38447 0.
4. Methodology for Managing the Gaps between UK HPR1000 Conventional Fire Safety Design and Conventional Fire Safety Codes and Standards. Document reference GH X 40300 005 DOZJ 03 GN, revision C, January 2018. TRIM 2018/0297.
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12. Pre-Construction Safety Report, Chapter 25, Conventional Safety and Fire Safety. Document Number; GH X 00620 025 KPGB 02 GN, revision B. September 2018. TRIM 5.1.3.10176.
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